INCH-POUND

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25 April 1991

SUPERSEDING
MIL-R-23417A
27 June 1975

MILITARY SPECIFICATION

# RESOLVERS, ELECTRICAL, AC GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

## 1. SCOPE

1.1 Scope. This specification relates to electrical resolvers. It is not complete in itself, but must be used in conjunction with MIL-S-81963 in which the latter will be recognized as forming an inherent part of this specification. (See 6.2.)

1.2 Classification.

1.2.1 Nomenclature. The nomenclature should consist of the item name, Resolver, Electrical, AC, followed by a type designation and a Part Identifying Number (PIN) (see 6.2). All resolvers having the same design nomenclature must be physically, mechanically, and electrically interchangeable for all military applications. The type designation is indicated by a combination of digits and letters. Illustrated in Table I is the complete nomenclature for a resolver type 23R32N4B.

1.2.1.1 Size. The first two numerals indicate the maximum external diameter of the resolver in tenths of an inch. If the diameter is not exactly a whole number of tenths, the next higher tenth is used; for example, "23" indicates a resolver with a maximum body diameter of 2.250 inches.

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| Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document, should be addressed to: Commander, U.S. Army ARDEC, Attn: SMCAR-BAC-S, Picatinny Arsenal, New Jersey 07806-5000 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter. |

AMSC N/A FSC 5990

1.2.1.2 Function. The letter "R" after "Size" specifies the unit is a resolver.

1.2.1.3 Impedance of primary winding. The numerals following the "Function" indicate the nominal impedance of the primary winding in hundreds of ohms. If the impedance is not exactly a whole number of hundreds, the next higher hundred is used.

1.2.1.4 Compensation. After "Impedance of primary winding," compensation is indicated as follows:

| | |
|---|---|
| Winding compensated | W |
| Not compensated | N |

1.2.1.5 Rated frequency code. The compensation-denoting letter is followed by numerals indicating the rated frequency of the system power supply from which the resolver is designed to operate.

| Rated Frequency (Hz) | Code |
|---|---|
| 60 | 6 |
| 400 | 4 |
| 800 | 8 |
| 1000 | 10 |
| 10000 | 100 |
| 20000 | 200 |

* NOTE *

The designation of the resolver by the frequency code "6" does not imply that 60 Hz must necessarily be used. It will generally be possible to employ a 50 Hz supply with a device to reduce the voltage appropriately, although certain of the resolver characteristics will thereby be modified.

1.2.1.6 Modification. The upper case letter "A" following the frequency digit indicates the original or basic design standard of the resolver type. The first modification to affect the physical interchangeability or the performance characteristics of the basic type is indicated by the upper case letter "B", and succeeding modifications are indicated by "C", "D", etc., except the use of letters "I", "L", "O", and "Q" is prohibited.

1.2.1.7 Part identifying number. The part identifying number following the modification letter consists of the letter "M", the specification sheet number (not including the revision letter), an assigned dash number, and an upper case suffix letter designating the latest modification letter in the type designation, as illustrated in Table II.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

MILITARY

| | |
|---|---|
| MIL-W-16878/4 | Wire, Electrical, Polytetraflouroethylene (PFTE), Insulated, 200°C, 600 Volts, Extruded Insulation |
| MIL-S-81963 | Servocomponents, Precision Instrument, Rotating, Common Requirements and Tests, General Specification For |

(See Supplement 1 for list of MIL-R-23417 specification sheets.)

STANDARDS

MILITARY

| | |
|---|---|
| MS17182 | Terminal Lug, Crimp Style, Copper, Insulated (Servocomponents), Type II, Class I, for 125°C Total Conductor Temperature |
| MS17183 | Clamp Assembly (Synchro) |
| MS17186 | Washer, Drive (Synchro) |
| MS17187 | Nut, Plain, Hexagon |
| MS35275 | Screw, Machine-Drilled Fillister Head, Slotted, Corrosion-Resisting Steel, Passivated, UNC-2A |
| MS35276 | Screw, Machine-Drilled Fillister Head, Slotted, Corrosion-Resisting Steel, Passivated, UNF-2A |
| MS35338 | Washer, Lock-Spring, Helical, Regular (Medium) Series |
| MS90406 | Gage, Ring, Spline (Go-No Go) |

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Naval Publications and Forms Center (Attn: Documents Order Desk), Bldg. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

2.2 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for related associated detail specifications, specification sheets, or MS standards), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained, in which case the exception will be identified in the text and cited in the solicitation.

3. REQUIREMENTS

3.1 Specification sheets. The individual item requirements shall be as specified herein, in MIL-S-81963, and in accordance with the applicable specification sheet. In the event of any conflict between the requirements of MIL-S-81963, this specification and the specification sheet, the latter shall govern.

3.2 First article. When specified (see 6.2), a sample shall be subjected to first article inspection (see 6.3) in accordance with 4.3.

3.4 Design conventions.

3.4.1 Parts, materials and processes. Resolvers shall be constructed of parts and materials in accordance with MIL-S-81963.

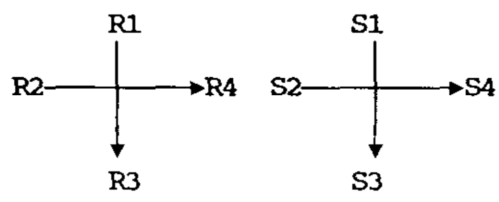
3.4.2 Direction of rotation. The standard (positive) direction of rotation of the shaft is counterclockwise when the resolver is viewed from the shaft extension end.

3.4.3 Electrical angle. The electrical angle is the angle $\theta$ in the equations which define the ideal magnitude and polarity relationships among secondary voltages. Defining equations for any rotor angle and diagrams of relative instantaneous polarity at resolver zero are as follows:

3.4.3.1 Rotor-energized resolvers.

$$E(S1S3)=NE(R1R3)\cos\theta - NE(R2R4)\sin\theta$$
$$E(S2S4)=NE(R2R4)\cos\theta + NE(R1R3)\sin\theta$$

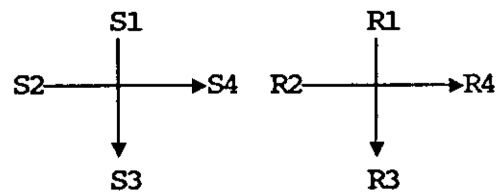
where N = transformation ratio



3.4.3.2 Stator-energized resolvers.

$$E(R1R3) = NE(S1S3)\cos\theta + NE(S2S4)\sin\theta$$
$$E(R2R4) = NE(S2S4)\cos\theta - NE(S1S3)\sin\theta$$

where N = transformation ratio




3.4.4 Resolver zero. Resolver zero is the position of the rotor shaft for which the electrical angle is zero. The electrical angle is zero when the position of the rotor with respect to the stator satisfies the secondary voltage polarity relationships of 3.4.2 for the resolver zero position, and minimum voltage is induced in the specified secondary winding. The minimum voltage occurs at the rotor position where the fundamental frequency component is zero and the secondary voltage at that point is in time phase with the maximum value of secondary voltage for the same winding. The pertinent maximum value of secondary voltage is the first maximum position encountered when the rotor is turned in the positive direction from resolver zero.

3.4.4.1 Rotor-energized resolvers. Resolver zero occurs for rotor-energized resolvers when windings R1R3 and S2S4 are at minimum coupling and is determined in accordance with Figure 1.

3.4.4.2 Stator-energized resolvers. Resolver zero occurs for stator-energized resolvers when windings S1S3 and R2R4 are at minimum coupling and is determined in accordance with Figure 2.

3.5 Design and construction.

3.5.1 Terminal and lead wire identification. When screw and solder pin terminals are designated, the terminals shall conform to the specifications of MIL-S-81963. When wire leads are used, the wire shall be in accordance with MIL-W-16878/4, Type E-28. Unless otherwise specified, wire leads shall be a minimum of 18 inches long, and shall be capable of being pulled, bent, and twisted as required in MIL-S-81963. Sleeves for wire leads shall be approximately one inch long. Terminal and lead wire identification marking for terminal screw, solder pin or wire lead type shall be in accordance with Table III. Terminal hardware is listed in Table IV.

3.5.2 Resolver configuration dimensions. Resolver configurations including lettered dimensions shall be in accordance with the applicable outline drawings shown on Figures 3, 4 and 5. Lettered dimensions are provided in Table V. Figures are not drawn to scale; for example, the stop on the shaft may not correspond to its true position, particularly in the size 11 and 15 resolvers.

3.5.3 Spline data. The end function of the spline on these resolvers is as a rotational positive fastening. It is not to be used as a gear. The tooth form shall be full depth involute. The spline shall be inspected by MS90406.

3.6 Performance.

3.6.1 Visual and mechanical inspection. Visual and mechanical inspection shall be performed in accordance with 4.11.1 and shall meet the requirements of MIL-S-81963.

3.6.2 Shaft radial and end play. Shaft radial and end play of the resolver rotor shaft shall be tested in accordance with 4.11.2, and shall meet the specified limits of the applicable specification sheet.

3.6.3 Shaft runout. When tested in accordance with 4.11.3, total runout of the smooth portion of the shaft shall not exceed the specified limits of the applicable specification sheet.

3.6.4 Variation of brush contact resistance. Following the test of 4.11.4, the variation of brush contact resistance between winding terminations R2R4 and R1R3 of the resolver shall be as specified in MIL-S-81963.

3.6.5 Mechanical breakaway torque. Mechanical breakaway torque shall be tested in accordance with 4.11.5, and the torque required to turn the resolver rotor shaft shall not exceed the value specified in the applicable specification sheet.

3.6.6 Dielectric withstanding voltage. When tested in accordance with 4.11.6 and Table VI, the resolver shall meet the requirements of MIL-S-81963.

3.6.7 Insulation resistance. Unless otherwise specified in the applicable specification sheet, the insulation resistance between the application points designated in Table VI shall be measured in accordance with 4.11.7, and shall not be less than the values specified in MIL-S-81963.

3.6.8 Current. The current drawn by each primary winding shall be in accordance with 4.11.8, and shall be within the limits specified in the applicable specification sheet.

3.6.9 Power. The power consumption of each primary winding shall be in accordance with 4.11.9, and shall be within the limits specified in the applicable specification sheet.

3.6.10 Transformation ratio. (See 6.4.14).

3.6.10.1 Rotor-energized. The transformation ratio for each stator/rotor winding combination shall be within the specified limits of the applicable specification sheet when measured in accordance with 4.11.10.1.

3.6.10.2 Stator-energized. The transformation ratio for each rotor/stator or rotor/compensator winding combination shall be within the specified limits of the applicable specification sheet when measured in accordance with 4.11.10.2.

3.6.10.3 Transformation ratio variation with voltage. When tested in accordance with 4.11.10.3, the transformation ratio for each winding combination with maximum and minimum operating voltages shall be within the limits specified in the applicable specification sheet in comparison to the value obtained at the test voltage.

3.6.10.4 Equality of transformation ratios. When tested in accordance with 4.11.10.4, the maximum difference between the transformation ratios measured in 3.6.10.1 and 3.6.10.2 shall be within the limits specified in the applicable specification sheet.

3.6.11 Phase shift. (See 6.4.9.)

3.6.11.1 Rotor-energized. The phase shift for each stator/rotor winding combination shall be within the limits specified in the applicable specification sheet when measured in accordance with 4.11.11.1.

3.6.11.2 Stator-energized. The phase shift for each rotor/stator or rotor/compensator winding combination shall be within the limits specified in the applicable specification sheet when measured in accordance with 4.11.11.2.

3.6.11.3 Phase shift variation with voltage. When measured in accordance with 4.11.11.3, the phase shift variation for each winding combination at maximum and minimum operating voltages shall not exceed the limits specified in the applicable specification sheet.

3.6.12 Function error. (See 6.4.4)

3.6.12.1 Stator-energized. When tested in accordance with 4.11.12.1, function error shall not exceed the value specified in the applicable specification sheet.

3.6.12.2 Rotor-energized. When tested in accordance with 4.11.12.2, function error shall not exceed the value specified in the applicable specification sheet.

3.6.13 Electrical error. (See 6.4.3) Electrical error shall not exceed the value specified in the applicable specification sheet when tested in accordance with 4.11.13.

3.6.14 Residual (null) voltage. (See 6.4.11) Fundamental and total residual voltages shall be within the limits specified in the applicable specification sheet when tested in accordance with 4.11.14.

3.6.15 Interaxis error. (See 6.4.8) Interaxis error shall not exceed the value specified in the applicable specification sheet when tested in accordance with 4.11.15.

3.6.16 Impedance. (See 6.4.6) Rotor, stator, and where applicable, compensating winding impedances shall be taken in accordance with 4.11.16, and shall be within the limits specified in the applicable specification sheet.

3.6.17 Compensating windings.

3.6.17.1 Residual voltage, compensating windings. Fundamental residual voltage of compensating windings shall be within the limits specified in the applicable specification sheet when tested in accordance with 4.11.17.1.

3.6.17.2 Winding phase, compensating windings. Like-numbered terminations of stator and compensating windings shall be of the same polarity when the resolver is energized at its test voltage in accordance with 4.11.17.2.

3.6.18 Resolver zero marking. Resolver zero marking shall be accomplished in accordance with 4.11.18, and shall meet the requirements of MIL-S-81963 and the applicable specification sheet.

3.6.19 Security of terminals or wire leads. The security of each screw type or solder pin type of terminal or of each wire lead, as applicable to the particular type of resolver, shall be tested in accordance with 4.11.19 and shall meet the requirements of MIL-S-81963.

3.6.20 Harmonic distortion. (See 6.4.5) Harmonic distortion shall not exceed the value specified in the applicable specification sheet when tested in accordance with 4.11.20.

3.6.21 Shift of resolver zero.

3.6.21.1 Variation with voltage. The change of position of resolver zero with variation of maximum and minimum primary voltage shall be performed in accordance with 4.11.21.1, and shall be within the limits as specified in the applicable specification sheet.

3.6.21.2 Variation with frequency. When checked in accordance with 4.11.21.2, the change of position of resolver zero shall be within the limits as specified in the applicable specification sheet.

3.6.22 Resonant frequency response. When tested in accordance with 4.11.22, the resolver shall meet the minimum requirement for resonant frequency response for each primary winding combination as specified in the applicable specification sheet.

3.6.23 Temperature rise. When tested in accordance with 4.11.23, the temperature rise calculated from the expression in MIL-S-81963 shall not exceed the value specified in the applicable specification sheet.

3.6.24 Electromagnetic interference. Electromagnetic conducted and radiated interference of the resolver shall be tested in accordance with 4.11.24, and shall not exceed the limits of MIL-S-81963.

3.7 Environmental.

3.7.1 Vibration. The resolvers shall be tested in accordance with 4.12.1, and shall meet the requirements specified in MIL-S-81963 and Table VII herein.

3.7.2 Shock.

3.7.2.1 Shock, low impact. The resolvers shall be tested in accordance with 4.12.2.1, and shall meet the requirements specified in MIL-S-81963 and Table VII herein.

3.7.2.2 Shock, high impact. The resolvers shall be tested in accordance with 4.12.2.2, and shall meet the requirements specified in MIL-S-81963 and Table VII herein.

3.7.3 Altitude.

3.7.3.1 Altitude, low temperature. The resolvers shall be tested in accordance with 4.12.3.1, and shall meet the requirements of MIL-S-81963 and Table VII herein.

3.7.3.2 Altitude, high temperature. The resolvers shall be tested in accordance with 4.12.3.2, and shall meet the requirements of MIL-S-81963 and Table VII herein.

3.7.4 Ambient temperature.

3.7.4.1 Ambient low temperature. The resolvers shall be tested in accordance with 4.12.4.1, and shall meet the requirements of MIL-S-81963 and Table VII herein.

3.7.4.2 Ambient high temperature. The resolvers shall be tested in accordance with 4.12.4.2, and shall meet the requirements of MIL-S-81963 and Table VII herein.

3.7.5 Endurance. The resolvers shall be tested in accordance with 4.12.5, and shall meet the requirements of Table VII as listed herein.

3.7.6 Moisture resistance. The resolvers shall be tested in accordance with 4.12.6, and shall meet the requirements of Table VII herein.

3.7.7 Explosion resistance. When required by the applicable specification sheet, the resolvers shall be tested in accordance with 4.12.7, and shall meet the requirements of MIL-S-81963.

3.7.8 Salt atmosphere. When required by the applicable specification sheet, the resolvers shall be tested in accordance with 4.12.8, and shall meet the requirements of MIL-S-81963.

3.8 Identification marking. The resolvers shall meet the identification marking requirement as specified in MIL-S-81963. The nomenclature to be employed shall be in accordance with 1.2.1 and the applicable specification sheet.

3.9 Workmanship. The resolver shall meet the workmanship requirements of MIL-S-81963.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in this inspection where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements; however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

4.2 Classification of inspections.

a. First article inspection (see 4.3)

b. Quality conformance inspection (see 4.4)

4.3 First article inspection. When required by the procuring activity (see 6.2), first article inspection shall be in accordance with MIL-S-81963.

4.4 Quality conformance inspection. Quality conformance inspection shall be in accordance with MIL-S-81963 and Table VII herein.

4.5 General. Unless otherwise specified herein or in the applicable specification sheet, all testing shall be conducted in accordance with MIL-S-81963.

4.6 Test conditions. Unless otherwise specified, each test shall be carried out with the resolver mounted in a standard test fixture applicable to its frame size in accordance with MIL-S-81963. An equivalent induction type resolver bridge or resolver standard, where applicable, may be used for electrical error testing.

4.6.1 Angular accuracy test stand. When specified, the angular accuracy test stand shall be an angular dividing device by which angular positions may be set with an error no greater than ± 15 seconds of arc. The means adopted to mount the resolver shall be such that accumulated tolerances do not introduce an error due to lack of concentricity greater than 30 seconds of arc.

4.7 Temperature, stabilized non-operating. The stabilized non-operating temperature of the resolver shall be as specified in MIL-S-81963 using a secondary winding for the periodic dc resistance measurement.

4.8 Temperature, stabilized operating. The stabilized operating temperature of the resolver shall be as specified in MIL-S-81963 using a secondary winding for the periodic dc resistance measurement.

4.9 Test voltage and frequencies. The test voltage and frequency of the resolver are those specified for the primary winding in the applicable specification sheet. Performance values and their limits stated in the applicable specification sheets are based on ±1 percent tolerance on voltage and frequency, on 1 percent harmonic content, and on test conditions which are closely controlled. Unless otherwise specified, the amplitude and frequency of test voltages shall be within 1 percent of the rated or specified value. The total harmonic content of test voltages shall not exceed 1 percent of the amplitude of the voltage of fundamental frequency. In addition, at all corresponding ordinates, the divergence of the waveform of the test voltage from that of a pure sine wave of the same rms value shall not exceed 1 percent of the instantaneous value of the sine wave.

4.10 Degradation of performance. The following minor relaxations in specified requirements may be permitted at the discretion of the qualifying activity.

4.10.1 Quality conformance tests. All the specified performance requirements must be attained.

4.10.2 Environmental tests. As appropriate during or following each of the environmental tests, the following minor relaxations in specified requirements may be permitted. It should be noted that the relaxations are not cumulative; for example, if function error is accepted at up to 0.01 percent in addition to the specified maximum value following vibration, the function error shall still not be more than 0.01 percent in addition to the specified maximum value following low impact shock.

4.10.2.1 Variation of brush contact resistance. A maximum variation of 1.5 ohms or 0.75 percent of rotor dc resistance specified in the specification sheet may be permitted. Following high impact shock, a maximum variation of 2.25 ohms or 1.125 percent of rotor dc resistance stated in the specification sheet is allowed.

4.10.2.2 Function error. An increase of 0.01 percent in addition to the maximum percent function error value specified in the specification sheet may be permitted. Following high impact shock, an increase up to 1.5 times the maximum percent function error value required in the specification sheet is allowed.

4.10.2.3 Electrical error. An increase of one minute of arc in addition to the maximum electrical error value specified in the specification sheet may be permitted. Following high impact shock, an increase up to 1.5 times the maximum electrical error required in the specification sheet is allowed.

4.10.2.4 Mechanical breakaway torque. An increase to two times the maximum mechanical breakaway torque specified in the specification sheet at standard test temperature may be permitted. Following high impact shock, an increase up to three times the maximum breakaway torque value required on the specification sheet at standard test temperature is allowed.

4.10.2.5 Shaft radial play. The maximum permissible radial play is 1.5 times the maximum value stated in the specification sheet. Following high impact shock, radial play shall not exceed 2.25 times the maximum value stated on the specification sheet value.

4.10.2.6 Shaft end play. Regardless of the limits stated in the specification sheet, a minimum end play of 0.0002 inch is required. The maximum permissible end play is 1.66 times the maximum value specified in the specification sheet. Following high impact shock, end play shall not exceed 2.5 times the maximum value stated on the specification sheet.

4.10.2.7 Residual (null) voltage. Following high impact shock, an increase of 50 percent of the maximum fundamental and total residual voltage values specified in the specification sheet is allowed.

4.10.2.8 Dielectric withstanding voltage. Following high impact shock, the winding leakage current shall not exceed 1.5 mA when 80 percent of the test voltage is applied.

4.10.2.9 Insulation resistance. Following high impact shock and having been immediately preceded by dielectric withstanding, a reduction to 25 megohms insulation resistance is allowed.

4.10.3 Major failures during or following environmental tests. Allowances having been made for the relaxations quoted in 4.10.2, major failures experienced during or following environmental tests shall be cause for refusal to grant first article approval.

4.11 Test methods and examinations.

4.11.1 Visual and mechanical examination. The resolver shall be examined in accordance with MIL-S-81963 and shall meet the requirements of 3.6.1 herein.

4.11.2 Shaft radial and end play. Shaft radial and end play shall be tested in accordance with MIL-S-81963 and shall meet the requirements of 3.6.2 herein.

4.11.3 Shaft runout. Total runout of the smooth portion of the shaft shall be performed in accordance with MIL-S-81963 and shall meet the requirements of 3.6.3 herein.

4.11.4 Variation of brush contact resistance. The variation of brush contact resistance between terminals R2R4 and R1R3 of the resolver shall be tested in accordance with MIL-S-81963 and shall meet the requirements of 3.6.4.

4.11.5. Mechanical breakaway torque. Mechanical breakaway torque shall be tested in accordance with MIL-S-81963 and shall meet the requirements of 3.6.5.

4.11.6 Dielectric withstanding voltage. Dielectric withstanding voltage shall be tested in accordance with MIL-S-81963 and Table VI herein and shall meet the requirements of 3.6.6.

4.11.7 Insulation resistance. Insulation resistance shall be tested in accordance with MIL-S-81963 and Table VI herein and shall meet the requirements of 3.6.7. For resolvers with maximum operating voltages greater than 50 volts rms, 100 volts dc shall be applied between application points involving windings in intimate contact and 500 volts dc shall be applied between all other application points. For resolvers with maximum operating voltages less than 50 volts rms, 100 volts dc shall be applied between all application points.

4.11.8 Current. The current shall be tested in accordance with MIL-S-81963. The resolver shall be brought to the stabilized operating temperature condition of 4.8 and the current drawn by each primary winding, when energized in accordance with 4.9 and with all other windings open-circuited, shall meet the requirements of 3.6.8.

4.11.9 Power. The power shall be measured in accordance with MIL-S-81963. The resolver shall be brought to the stabilized operating temperature condition of 4.8 and the power consumed by each primary winding, when energized in accordance with 4.9 and with all other windings open-circuited, shall meet the requirements of 3.6.9.

4.11.10 Transformation ratio.

4.11.10.1 Rotor-energized. The resolver shall be mounted in the angular accuracy test stand in accordance with 4.6.1, brought to the stabilized operating temperature condition of 4.8, energized in accordance with 4.9, and set at resolver zero in accordance with the applicable figure of 3.4.4. The resolver shall then be connected and the rotor positioned in accordance with Table VIII as applicable. The secondary winding voltage at the position of maximum coupling shall be measured with a fundamental frequency, rms-voltage-indicating instrument that shall not alter the open-circuited secondary voltage by more than 0.05 percent. The ratio of this secondary winding voltage to the primary energization winding voltage is the transformation ratio which shall be in accordance with the requirements of 3.6.10.1.

4.11.10.2 Stator-energized. The test conditions of 4.11.10.1 shall be followed and the transformation ratio shall be measured at terminals R1R3 and R2R4 for both S1S3 and S2S4 energization. Rotor-to-compensating winding values are obtained by calculation based on rotor/stator and compensating/stator winding measured values, $R/C = R/S \div C/S$, at the maximum coupling position nearest resolver zero. The transformation ratio shall meet the requirements of 3.6.10.2.

4.11.10.3 Variation with voltage. The transformation ratio shall be measured at the maximum and minimum operating voltages specified in the applicable specification sheet under the test conditions of 4.11.10.1 and shall meet the requirements of 3.6.10.3.

4.11.10.4 Equality of transformation ratios. The maximum difference between measured transformation ratios of 4.11.10.1 or 4.11.10.2 shall be in accordance with the requirements of 3.6.10.4.

4.11.11 Phase shift.

4.11.11.1 Rotor-energized. The resolver shall be mounted in an angular accuracy test stand in accordance with 4.6.1, brought to the stabilized operating temperature condition of 4.8, energized in accordance with 4.9, and set at resolver zero in accordance with the applicable figure of 3.4.4. The resolver shall then be connected and the rotor positioned in accordance with Table VIII as applicable. The phase shift shall be measured at the position of maximum coupling to an accuracy of ± 0.10 degrees with an instrument having a primary impedance of not less than 500K ohms resistance shunted by a 30 pF capacitance. The phase shift shall be in accordance with the requirements of 3.6.11.1.

4.11.11.2 Stator-energized. The test of 4.11.11.1 shall be applied with the following terminal substitutions: S1S3 for R1R3, S2S4 for R2R4, R1R3 for S1S3, and R2R4 for S2S4. Rotor-to-compensating winding values are obtained by calculation based on rotor/stator and compensating/stator winding measured values, R/C = R/S - C/S,

where:

R/C is the total rotor-to-compensating winding phase shift in degrees
R/S is the rotor-to-stator winding phase shift in degrees
C/S is the compensating-to-stator winding phase shift in degrees.

Phase shift measurements shall meet the requirements of 3.6.11.2.

4.11.11.3 Phase shift variation with voltage. The tests of 4.11.11.1 and 4.11.11.2 shall be repeated using the minimum and maximum operating voltages specified in the applicable specification sheet. The phase shift variation with primary voltage change shall be in accordance with the requirements of 3.6.11.3.

4.11.12 Function error.

4.11.12.1 Stator-energized. The resolver shall be mounted in an angular accuracy test stand in accordance with 4.6.1, brought to the stabilized operating temperature condition of 4.8 and terminals S1S3 shall be energized in accordance with 4.9. The rotor shall first be set to the approximate zero position by aligning the shaft and housing zero indexes, and then to the exact zero position by obtaining a null across terminals R2R4 using the circuit shown on Figure 2. The resolver shall be connected as shown on Figure 6 and the rotor angle set at 90 degrees with the "read-out" transformer set to 1.00000. The normalizing transformer and phase shift capacitor shall be adjusted to give the minimum null voltage reading of the phase sensitive nullmeter. The normalizing transformer and phase shift capacitor shall not be readjusted throughout the remainder of the test. The "read-out" transformer setting that results in a minimum reading of the phase sensitive nullmeter minus the sine of the rotor angle times 100 gives the function error as a percentage of maximum output. The function error shall be determined at 5-degree rotor angle increments from 0 through 360 degrees, and the test shall be repeated substituting the following terminal connections: S2S4 for S1S3; R1R3 for R2R4. At 180 degrees, the polarity of the energizing windings must be reversed for both tests. The function error shall be in accordance with the requirements of 3.6.12.1.

4.11.12.2 Rotor-energized. The test conditions of 4.11.12.1 shall apply to rotor-energized resolvers except for the following terminal substitutions: R1R3 for S1S3; R2R4 for S2S4; S1S3 for R1R3; S2S4 for R2R4. The function error shall be in accordance with the requirements of 3.6.12.2.

4.11.13 Electrical error. Resolvers shall be tested for electrical error by either of the proportional voltage methods described in 4.11.13.1 or 4.11.13.2. The electrical error shall be measured and recorded at rotor angular increments of not more than 5 degrees from zero through 360 degrees, and shall be in accordance with the requirements of 3.6.13.

4.11.13.1 Proportional voltage nulling method.

4.11.13.1.1 Stator error, rotor-energized resolvers. The resolver shall be mounted in accordance with 4.6.1, brought to the stabilized operating temperature condition of 4.8 and terminals R1R3 shall be energized in accordance with 4.9. The rotor shall first be set to the approximate zero position using the index marks on the shaft and housing, and then to the exact zero position using the circuit on Figure 1. The resolver shall then be connected to the test circuit on Figure 7 and the error shall be determined. The electrical error of the resolver is the deviation from the (mechanical) rotor angle to balance the bridge for the following ratios:

$$\frac{A1}{A2} = \tan\theta, \text{ for } \theta = \frac{n\pi}{2} - \frac{\pi}{4} \text{ to } \frac{n\pi}{2} + \frac{\pi}{4}, \text{ for n positive even integers } (n = 0, 2, 4, 6, \text{etc.})$$

$$\frac{A2}{A1} = \text{cotan}\,\theta, \text{ for } \theta = \frac{n\pi}{2} - \frac{\pi}{4} \text{ to } \frac{n\pi}{2} + \frac{\pi}{4}, \text{ for n positive odd integers } (n = 1, 3, 5, 7, \text{etc.})$$

| Tan | Cot | A1/A2, A2/A1 |
|---|---|---|
| 0° | 90° | 0.000000 |
| 5 | 85 | 0.087488 |
| 10 | 80 | 0.176327 |
| 15 | 75 | 0.267949 |
| 20 | 70 | 0.363970 |
| 25 | 65 | 0.466307 |
| 30 | 60 | 0.577350 |
| 35 | 55 | 0.700207 |
| 40 | 50 | 0.839099 |
| 45 | 45 | 1.000000 |

In the bridge on Figure 7, the resistor arms S3S4, S1S2 and the divider arms S3S2, S1S4 shall be non-inductive resistors of nominal value 10K ohms and shall be equal to within 1 ohm. The angle taps of the dividers A1/A2, A2/A1 shall be within 0.005 percent of the theoretical values stated. The phase shift of the divider shall be less than 10 minutes of arc at the test frequency. The phase-sensitive nullmeter shall have an input impedance not less than 500K ohms shunted by 30 pF capacitance. The minimum indication of the phase- sensitive nullmeter shall be less than the voltage equivalent to 0.2 minute of arc displacement from the null position of the resolver under test when energized in accordance with 4.9. The phase-sensitive nullmeter rejection shall be such that a quadrature input of 0.2 percent of the test resolver maximum voltage output, coupled with a harmonic input of 1 percent of the test resolver maximum voltage input, shall not produce a greater meter indication than a test resolver rotor displacement of 0.2 minute of arc from the null position.

4.11.13.1.2 Stator error, stator-energized resolvers. The basic circuit for electrical testing of stator error of stator-energized resolvers is shown on Figure 8. The stator terminals of the stator-energized resolver under test are connected to the stator terminals of the rotor-energized resolver, of equal or larger frame size, which has successfully completed the electrical error tests of 4.11.13.1 and which is energized in accordance with 4.9. The bridge voltage dividers are to be set to the ratios appropriate to the rotor angle of the resolver under test (defined in 4.11.13.1.1) and the energizing resolver shaft position adjusted to null the bridge output. The shaft position of the resolver under test is adjusted to null its phase-sensitive nullmeter (No. 2). The electrical error is the deviation of the rotor angle from the value used to set the bridge voltage divider ratios.

4.11.13.1.3 Rotor error, stator-energized resolvers. The test of 4.11.13.1.1 for stator error of rotor-energized resolvers shall apply to rotor error of stator-energized resolvers with the following terminal substitutions: S1S3 for R1R3; S2S4 for R2R4; R1R3 for S1S3; and R2R4 for S2S4.

4.11.13.2 Proportional voltage gradient method.

4.11.13.2.1 Stator error, rotor-energized resolvers. The basic circuit is shown on Figure 9. The circuit and operation are similar to that of 4.11.13.1.1, except that the phase-sensitive nullmeter has been replaced by a calibrated phase-sensitive amplifier with compensating network, an indicator and recorder. The calibrated phase-sensitive amplifier with compensating network shall meet the loading and quadrature voltage rejection requirements (for the phase-sensitive nullmeter) of 4.11.13.1.1 and shall have constant voltage gradient (defined as electrical output per unit rotor deviation) at all bridge settings. The resolution of the indicator and recorder shall be such that an electrical error of 30 arc seconds may be determined without interpolation. The electrical error for a given rotor position is defined as the indicator/recorder reading divided by the voltage gradient when the bridge voltage dividers are set to the appropriate ratios for that rotor angle as defined in 4.11.13.1.1.

4.11.13.2.2 Stator error, stator-energized resolvers. The basic circuit is shown in Figure 10. The circuit and operation are similar to that of 4.11.13.1.2, except that phase-sensitive null meter No. 2 has been replaced by a phase-sensitive calibrated amplifier with compensating network indication and recorder as defined in 4.11.13.2.1. The resolver under test is set to the rotor position at which the electrical error is to be measured, and the bridge and energizing resolver set up and adjusted appropriately for the rotor position of the resolver under test as described in 4.11.13.1.2. The electrical error is the indicator/recorder reading divided by the voltage gradient as defined in 4.11.13.2.1.

4.11.13.2.3 Rotor error, stator-energized resolvers. The test shall be carried out as in 4.11.13.2.1 and Figure 9 (stator error, rotor-energized resolvers) with the following terminal substitutions: S1S3 for R1R3; S2S4 for R2R4; R1R3 for S1S3; and R2R4 for S2S4.

4.11.14 Residual (null) voltage. Fundamental and total residual voltages shall be measured across the terminals and at the angles specified in Table IX. The resolver shall be mounted in the angular accuracy test stand in accordance with 4.6.1, brought to the stabilized operating temperature condition of 4.8, and energized in accordance with 4.9. These residual voltages may be measured by method 4.11.14.1 or 4.11.14.2. The voltage measuring instruments used shall indicate the value in terms of the rms value of an equivalent sine wave and shall have an input impedance not less than 500K ohms shunted by 30 pF. The fundamental and total residual voltages shall be in accordance with the requirements of 3.6.14.

4.11.14.1 Frequency sensitive voltmeter method. The frequency sensitive voltmeter to be used shall have a filter characteristic such that the output changes by not greater than ± 0.5 percent for a 1 percent change in frequency from the center frequency of the filter and by -97 percent (-30 dB) for a one octave change from the center frequency of the filter. The voltmeter shall be calibrated to allow for the center frequency insertion loss of the filter. The resolver rotor shall be turned to give a minimum reading on the frequency sensitive voltmeter. This is the fundamental component of the residual voltage. The voltage read by a non-frequency sensitive voltmeter at the same (undisturbed) rotor position is the total residual voltage.

4.11.14.2 Phase-sensitive voltmeter method. The resolver rotor shall be turned until the in-phase component of the residual voltage, as indicated by the phase-sensitive voltmeter, is zero. The quadrature reading is the fundamental component of the residual voltage. The voltage read by a non-phase-sensitive voltmeter is the total residual voltage.

4.11.15 Interaxis error. The resolver shall be mounted in an angular accuracy test stand in accordance with 4.6.1, brought to the stabilized operating temperature condition of 4.8, and each of the appropriate primary windings energized in turn in accordance with 4.9. The deviation of the null position from the nominal rotor electrical angles specified in Table IX (Interaxis Serial A through H) shall be recorded. The unenergized primary winding shall be shorted. The following interaxis errors (algebraic differences between the deviations) shall be tabulated:

Secondary winding: A-C, B-D, E-G, F-H

Primary winding: A-G, B-H, C-F, D-E

Resolver (overall): A-E, B-F, C-G, D-H

The interaxis errors shall be in accordance with the requirements of 3.6.15.

4.11.16 Impedance. Impedance shall be measured in accordance with MIL-S-81963 and Table X herein. The resolver shall be brought to the stabilized operating temperature of 4.8, energized in accordance with 4.9, and set to resolver zero. The impedance shall then be measured and shall meet the requirements of 3.6.16.

4.11.17 Compensating windings.

4.11.17.1 Residual (null) voltage. When the resolver is connected as shown on Figure 11, the reading of the nullmeter shall be in accordance with the requirements of 3.6.17.1.

4.11.17.2 Winding phase. When the resolver is connected as shown on Figure 12, the reading of the voltmeter shall be less than the primary test voltage. Winding phase shall be in accordance with the requirements of 3.6.17.2.

4.11.18 Resolver zero marking.

4.11.18.1 Rotor-energized resolvers. The resolver windings shall be connected as shown on Figure 13 and the rotor turned until the voltmeter minimum reading is obtained. The relative position of the resolver zero index marked on the housing and the index marked on the shaft shall be in accordance with the requirements of 3.6.18.

4.11.18.2 Stator-energized resolvers. Resolver zero shall be determined as in 4.11.18.1 except for the following terminal substitutions: S1S3, S2S4 for R1R3, R2R4; and R1R3, R2R4 for S1S3, S2S4. The relative position of the resolver zero index marked on the housing and the index marked on the shaft shall be in accordance with the requirements of 3.6.18.

4.11.19 Security of terminals or wire leads. The security of each screw type or solder-pin type of terminal or of each wire lead shall be tested in accordance with MIL-S-81963 and shall meet the requirements of 3.6.19.

4.11.20 Harmonic distortion. The resolver shall be mounted in an angular accuracy test stand in accordance with 4.6.1, brought to the stabilized operating temperature condition of 4.8 while energized in accordance with 4.9, and set at exact resolver zero as specified in 3.4.4.

4.11.20.1 Rotor-energized resolvers. After compliance with 4.11.20, the resolver shall then be connected as shown in Figure 14, and energized at the maximum operating voltage specified in the applicable specification sheet. The total harmonic distortion is the rms value of the difference of the amplitudes up to and including the 9th harmonic (expressed as a percentage of the energization voltage) in the energization voltage supply waveform and the S1S3 output, and shall be as specified in 3.6.20.

4.11.20.2 Stator-energized resolvers. Harmonic distortion shall be determined as in 4.11.20.1 except for the following terminal substitutions: S1S3, S2S4 for R1R3, R2R4; R1R3, R2R4 for S1S3, S2S4. Value shall be as specified in 3.6.20.

4.11.21 Shift of resolver zero.

4.11.21.1 Variation with voltage. The resolver shall be mounted in the angular accuracy test stand in accordance with 4.6.1, brought to the stabilized operating temperature condition of 4.8 while energized in accordance with 4.9, and set at exact zero as specified in 3.4.4. Energization shall then in turn be changed to the maximum and minimum primary voltages and the resolver zeroed at each of these. The shift of resolver zero shall be in accordance with the requirements of 3.6.21.2.

4.11.21.2 Variation with frequency. The test of 4.11.21.1 shall be repeated with the test voltage held constant in accordance with 4.9 and the resolver reset at zero when the operating frequency is first decreased by 10 percent and then increased by 10 percent. The shift in resolver zero shall be in accordance with the requirements of 3.6.21.2.

4.11.22 Resonant frequency response. The resolver shall be mounted in the angular accuracy test stand in accordance with 4.6.1, and brought to the stabilized operating temperature condition of 4.8 with one primary winding energized in accordance with 4.9. The rotor shall be set at the position of maximum coupling nearest resolver zero. The applicable secondary winding shall be monitored to ascertain the resolver has attained maximum voltage while simultaneously experiencing a -90 degree phase shift. The resonant frequency response shall be identified and recorded at this point. The same procedure shall be repeated with the exception that the other primary winding shall be energized and tested separately. The resolver shall meet the minimum requirement for resonant frequency response for each primary winding combination in accordance with the requirements of 3.6.22. Low corner frequency may be referenced on the specification sheet for design information only. Low corner frequency is the point where the output voltage is down 3 dB and the phase shift is 45°.

4.11.23 Temperature rise. The resolvers shall be tested in accordance with MIL-S-81963. After the resolver has attained the stabilized non-operating temperature condition of 4.7, the dc resistance of one of the secondary windings shall be measured. Both primary windings shall then be energized in accordance with 4.9, with the secondary windings unloaded. The dc resistance of the secondary winding measured prior to energization shall again be measured when the resolver has attained the stabilized operating temperature condition of 4.8. The temperature rise shall be in accordance with the requirements of 3.6.23.

4.11.24 Electromagnetic interference. The resolver shall be subjected to the electromagnetic interference test of MIL-S-81963. Both resolver primary windings shall be energized in accordance with 4.9, and the rotor shall be rotated at 600 ± 50 rpm. A load equivalent to four times the secondary winding open-circuit impedance shall be applied across both secondary windings. Compensating windings shall be unloaded. Electromagnetic conducted and radiated interference of the resolver shall be in accordance with the requirements of 3.6.24.

4.12 Environmental tests.

4.12.1 Vibration. The resolvers shall be tested in accordance with the requirements of MIL-S-81963. During the test, both rotor windings shall be energized in accordance with 4.9 with their rotor shafts free to rotate while mechanically loaded. In the case of a stator-energized resolver, the energizing voltage of both rotor windings shall be determined accordingly by the transformation ratio as specified in 3.6.10. Immediately after the test, each resolver shall be examined for loose or damaged parts and shall then be subjected to and shall meet the requirements of 3.7.1 and Table VII.

4.12.2 Shock.

4.12.2.1 Shock, low impact. The resolvers shall be tested in accordance with the requirements of MIL-S-81963. During the test, both rotor windings shall be energized in accordance with 4.9 with their rotor shafts free to rotate while mechanically loaded. In the case of a stator-energized resolver, the energizing voltage of both rotor windings shall be determined accordingly by the transformation ratio as specified in 3.6.10. Immediately after the test, each resolver shall be examined for loose or damaged parts and shall then be subjected to and shall meet the requirements of 3.7.2.1 and Table VII.

4.12.2.2 Shock, high impact. The resolvers shall be tested in accordance with the requirements of MIL-S-81963. During the test, both rotor windings shall be energized in accordance with 4.9 with their rotor shafts free to rotate while mechanically loaded. In the case of a stator-energized resolver the energizing voltage of both rotor windings shall be determined accordingly by the transformation ratio as specified in 3.6.10. Immediately after the test, each resolver shall be examined for loose or damaged parts and shall then be subjected to and shall meet the requirements of 3.7.2.2 and Table VII.

4.12.3 Altitude.

4.12.3.1 Altitude, low temperature. The resolvers shall be tested in accordance with the requirements of MIL-S-81963. After the attainment successively of the stabilized non-operating and stabilized operating temperature conditions as defined in 4.7 and 4.8, and the specified reduction of chamber pressure, the resolvers shall be energized in accordance with 4.9. While still in the specified environment, the resolvers shall be subjected to and shall meet the requirements of 3.7.3.1 and Table VII.

4.12.3.2 Altitude, high temperature. The resolvers shall be tested in accordance with the requirements of MIL-S-81963. The internal ambient temperature of the test chamber shall be raised to and controlled at 125 ± 2°C. After the attainment successively of the stabilized non-operating and stabilized operating temperature conditions as defined in 4.7 and 4.8 and the specified reduction of chamber pressure, the resolver shall be energized in accordance with 4.9. While still in the specified environment, the resolvers shall be subjected to and shall meet the requirements of 3.7.3.2 and Table VII.

4.12.4 Ambient temperature.

4.12.4.1 Ambient low temperature. The resolvers shall be tested in accordance with the requirements of MIL-S-81963. After having been allowed to attain the stabilized non-operating temperature condition of 4.7, and at the end of the one hour period at -55 ± 2°C, the resolvers shall be allowed to attain the stabilized operating temperature condition as defined in 4.8. While still in this low temperature environment, the resolvers shall be subjected to and shall meet the requirements of 3.7.4.1 and Table VII.

4.12.4.2 Ambient high temperature. The resolvers shall be tested in accordance with the requirements of MIL-S-81963. The resolvers shall be allowed to attain the stabilized non-operating temperature condition of 4.7 at 125 ± 2°C ambient temperature. The resolvers shall then be allowed to attain the stabilized operating temperature conditions as defined in 4.8 at 125 ± 2°C ambient temperature. While still in this environment, the resolvers shall be subjected to and shall meet the requirements of 3.7.4.2 and Table VII.

4.12.5 Endurance. The resolvers shall be tested for 2000 hours in accordance with the requirements of MIL-S-81963, while energized as specified in 4.9 and while rotating the rotor at 1150 ± 50 rpm. After completion of the endurance test, the resolvers shall be subjected to and shall meet the requirements of 3.7.6 and Table VII.

4.12.6 Moisture resistance. The resolvers shall be tested in accordance with the requirements of MIL-S-81963. With each resolver shaft horizontal, one resolver of the sample shall be energized in accordance with 4.9 and the other resolver shall be unenergized. After completion of the final 24-hour recovery period, the resolvers shall be subjected to and shall meet the requirements of 3.7.6 and Table VII.

4.12.7 Explosion resistance. When required by the applicable specification sheet, the resolvers shall be tested in accordance with the requirements of MIL-S-81963 and shall meet the requirements of 3.7.7.

4.12.8 Salt atmosphere. When required by the applicable specification sheet, the resolver shall be tested in accordance with the requirements of MIL-S-81963 and shall meet the requirements of 3.7.8.

4.13 Inspection of packaging. The sampling and inspection of the preservation and packaging, packing, and container marking shall be in accordance with the requirements of MIL-S-81963.

5. PACKAGING

5.1 Packaging requirements. The requirements for packaging shall be in accordance with MIL-S-81963. (See 6.2.)

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The resolvers are intended for use in applications which require performance of trigonometric computations, conversion between rectangular and polar coordinates, and transmission and reception of angular position data by one or more rotor shafts.

6.2 Acquisition requirements. Acquisition documents must specify the following:

a. Title, number, and date of the specification.

b. Title, number, and date of the applicable specification sheet, the complete nomenclature, and the military part number.

c. Issue of DODISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1.1).

d. Whether first article inspection is required (see 3.3).

e. Level of packaging and packing, if other than Level C (specified in 5.1).

6.3 First article. When first article inspection is required, information pertaining to the products covered by this specification should be obtained from the contracting activity for the specific contracts involved. Invitations for bids should provide that the Government reserves the right to waive the requirement for samples for first article inspection to those bidders offering a product which has been previously acquired or tested by the Government, and that bidders offering such products, who wish to rely on such production or test, must furnish evidence with the bid that prior Government approval is presently appropriate for the pending contract. Bidders should not submit alternate bids unless specifically requiested to do so in the solicitation.

6.4 Definitions. For the purpose of this specification, the following definitions apply.

6.4.1 Resolver, electrical, AC. An electrical resolver, AC, is a variably coupled transformer consisting essentially of a pair of stationary (stator) windings displaced electrically 90° one from the other, and a pair of rotating (rotor) windings also displaced electrically 90° one from the other and free to rotate within the stationary windings. Either rotor or stator may be designed to serve as the primary. The secondary voltages are trigonometric functions of the primary voltages and are determined by the transformation ratio between windings and by the angular displacement of the rotor with respect to the stator. Compensating windings (on stator) may be used to improve the operational performance of the resolver.

6.4.2 Electrical degree. An electrical degree is an arbitrary unit of time required for an alternating current to complete 1/360 of one cycle of the fundamental component of the primary voltage.

6.4.3 Electrical error. The electrical error is the difference between the rotor angle and the electrical angle at any rotor position. The tangent of the electrical angle is calculated from the voltages of both secondary windings when one primary winding is energized. Electrical error is measured in minutes of arc.

6.4.4 Function error. Function error is the difference (expressed as a percentage of the maximum in-phase component of the secondary voltage) between the in-phase component of the voltage of one secondary winding with one primary winding energized and the theoretical value of the secondary voltage. It is equivalent to:

$$\left(\frac{E\theta}{E(\theta = 90°)} - \text{Sin } \theta\right) \text{ X } 100$$

where:

$E\theta$ = the measured in-phase component at the fundamental frequency of the secondary voltage at rotor angle $\theta$.

$E(\theta = 90°)$ = the measured in-phase component at the fundamental frequency of the secondary voltage at rotor angle $\theta = 90°$.

6.4.5 Harmonic distortion. Harmonic distortion is the Fourier difference between the applied primary voltage waveform and the open circuit secondary voltage waveform.

6.4.6 Impedance.

6.4.6.1 Rotor impedance Zro. The rotor impedance Zro is the impedance of the rotor with the stator terminals open circuited.

6.4.6.2 Rotor impedance Zrs. The rotor impedance Zrs is the impedance of the rotor with the stator terminals short circuited.

6.4.6.3 Stator impedance Zso. The stator impedance Zso is the impedance of the stator with the rotor terminals open circuited.

6.4.6.4 Stator impedance Zss. The stator impedance Zss is the impedance of the stator with the rotor terminals short circuited.

6.4.6.5 Compensating impedance Zco. The compensating impedance Zco is the impedance of the compensating windings with the rotor and stator terminals open circuited.

6.4.6.6 Compensating impedance Zcs. The compensating impedance Zcs is the impedance of the compensating windings with the stator and rotor terminals short circuited.

6.4.7 In-phase component. The in-phase component is the fundamental frequency component of the secondary voltage that is in phase with the frequency component of the energizing voltage at the same instant.

6.4.8 Interaxis error. Interaxis error is the angular deviation of the null positions from true space quadrature. It is expressed as the algebraic difference between measured angular deviations for each combination of windings.

6.4.9 Phase shift. Phase shift is the difference (expressed in electrical degrees) between the time phase of the fundamental frequency component of the primary voltage and the time phase of the fundamental frequency component of the secondary voltage of the resolver at the first position of maximum coupling in the positive direction from resolver zero.

6.4.10 Rated (primary) voltage. The rated (primary) voltage of a resolver is the line voltage of the resolver's system power supply; such as, 115 or 26 volts or the voltage range over which the resolver is designed to operate.

6.4.11 Residual (null) voltage. Residual voltage in a resolver is the actual voltage present at the secondary winding at that position at which the in-phase secondary voltage is zero. This voltage consists of the quadrature component of the energizing frequency and a component which is made up of harmonics of the energizing frequency. Fundamental residual voltage is the quadrature component of the energizing frequency; total residual voltage is the fundamental residual voltage plus harmonics.

6.4.12 Rotor angle. The rotor angle is the angular mechanical displacement of the shaft from the defined resolver zero position measured in a positive direction.

6.4.13 Time phase. The time phase at any point in a resolver system is the phase of the voltage at that point with respect to the phase of the primary voltage of the system. The time phase is measured in electrical degrees.

6.4.14 Transformation ratio. The transformation ratio is the ratio of the fundamental frequency component of the open circuit secondary voltage and the primary voltage at maximum coupling.

6.4.15 Windings.

6.4.15.1 Compensating winding. An additional winding which modifies the characteristics of a primary winding, thus reducing imperfections which would otherwise be present in the secondary voltage.

6.4.15.2 Primary winding. A primary winding is one which receives energizing power from an external source.

6.4.15.3 Secondary winding. Any winding, other than a compensating winding, which gives an output when a primary winding is energized.

6.4.16 Units of measurement. Unless otherwise specified, units of measurement are as follows:

a. Angles - degrees and minutes
b. Potential - volts rms
c. Impedance - ohms
d. Current - amperes rms
e. Temperature - degrees Centigrade
f. Time phase - degrees
g. Time - seconds
h. Torque - ounce-inches
i. Angular velocity - revolutions per minute (rpm)

6.5 International standardization agreements. Certain provisions of this specification are the subject of international standardization agreements reached by the NATO Working Group on Analogue and Digital Servocomponents (AC/301(SG/A)(WG/5)). When amendment, revision, or cancellation of this specification is proposed which affects or violates the international agreement concerned, the preparing activity will take appropriate reconciliation action through international standardization channels including departmental standardization offices, if required.

6.6 Applicable international documentation. NATO documents applicable to this specification are Allied Standard Publication (AStanP)-3, Volume 5990 Chapter 2, NATO Electronic/Electrical Preferred Parts List, Resolvers, Electrical, AC; AStanP-4, Volume 5990 Chapter 4, NATO Electronic/Electrical Technical Recommendation, Resolvers, Electrical, AC; and AStanP-5, Volume 5990 Chapter 4, NATO Quality Assessment Recommendation for Electronic/Electrical Parts, Resolvers, Electrical, AC.

6.7 Performance criteria. Physical and performance criteria for individual resolver types are specified in the applicable specification sheets (see 3.1) and are based on a close tolerance power supply and on test conditions which are strictly controlled. Under service conditions, these values may be modified by the affects of power supply variations and of environmental conditions.

6.8 Subject term (key word) listing.

Angular accuracy
Compensating winding
Electrical angle
Electrical degree
Equality of transformation ratios
Function error
Harmonic distortion
In-phase component
Interaxis error
Phase shift
Resolver zero
Resonant frequency
Rotor angle
Residual (null) voltage
Rotor-energized resolvers
Servocomponent
Stator-energized resolvers
Variation of voltage

6.9 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

TABLE I. Nomenclature.

| Resolver | 23 | R | 32 | N | 4 | B |
|---|---|---|---|---|---|---|
| | (Type Designation) | | | | | |
| Item Name<br>1.2.1 | Size<br>1.2.1.1 | Function<br>1.2.1.2 | Impedance<br>1.2.1.3 | Compensation<br>1.2.1.4 | Frequency<br>1.2.1.5 | Modification<br>1.2.1.6 |

TABLE II. Example of part identifying number.

| M | 23417/16 | -01 | A |
|---|---|---|---|
| Military Designator | Specification Sheet Number | Dash Number | Latest Modification |

TABLE III. Termination identification marking.

| Terminal No. | Wire Lead Color | Winding |
|---|---|---|
| R1 | Red, White Tracer | Rotor, Start |
| R3 | Black, White Tracer | Rotor, Finish |
| R2 | Yellow, White Tracer | Rotor, Start |
| R4 | Blue, White Tracer | Rotor, Finish |
| S1 | Red | Stator, Start |
| S3 | Black | Stator, Finish |
| S2 | Yellow | Stator, Start |
| S4 | Blue | Stator, Finish |
| C1 | Red, Green Tracer | Compensating, Start |
| C3 | Black, Green Tracer | Compensating, Finish |
| C2 | Yellow, Green Tracer | Compensating, Start |
| C4 | Blue, Green Tracer | Compensating, Finish |

NOTE:

1. Terminal designations are such that the stator and compensating terminals with like numbers have like polarity when the resolver rotor angle is zero degrees.

TABLE IV. Terminal hardware.

| Hardware | Number Required | Military Standard | Resolver Size |
|---|---|---|---|
| Machine Screw | 8 EA | MS35276-201 | 11R7N4A |
| | 8 EA | " | 11R17N4A |
| | 7 EA | MS35276-203 | .25V-11R2N2A |
| | 7 EA | " | 26V-11R15N4B |
| | 7 EA | " | 26V-11R5N4A |
| | 7 EA | " | 9V-11R41N40A |
| | 12 EA | " | 11R23W4A |
| | 12 EA | " | 11R20W4A |
| | 8 EA | " | 11R2N4B |
| | 8 EA | " | 11R20N4A |
| | 8 EA | " | 11R1N4B |
| | 8 EA | " | 11R21N4B |
| | 8 EA | MS35275-213 | 15R2N4A |
| | 8 EA | " | 15R8N4A |
| | 8 EA | " | 15R28N4A |
| | 8 EA | " | 23R58N4A |
| | 12 EA | " | 15R28W4A |
| | 12 EA | " | 23R58W4A |
| | 12 EA | " | 15R11W4A |
| | 12 EA | " | 15R26W4A |
| | 12 EA | " | 23R32W4A |
| | 8 EA | MS35275-226 | 23R3N4A |
| | 8 EA | " | 23R8N4A |
| | 8 EA | " | 23R32N4A |
| Lock Washer | 8 EA | MS35338-134 | 11R7N4A |
| | 8 EA | " | 11R2N4B |
| | 8 EA | " | 11R20N4A |
| | 8 EA | " | 11R1N4B |
| | 8 EA | " | 11R21N4B |
| | 8 EA | " | 11R17N4A |
| | 12 EA | " | 11R23W4A |
| | 12 EA | " | 11R20W4A |
| | 7 EA | " | .25V-11R2N2A |
| | 7 EA | " | 26V-11R15N4B |
| | 7 EA | " | 26V-11R5N4A |
| | 7 EA | " | 9V-11R41N40A |
| | 8 EA | MS35338-135 | 15R2N4A |
| | 8 EA | " | 15R8N4A |
| | 8 EA | " | 15R28N4A |
| | 8 EA | " | 23R58N4A |
| | 12 EA | " | 15R28W4A |
| | 12 EA | " | 23R58W4A |
| | 12 EA | " | 15R11W4A |

TABLE IV. Terminal hardware - Continued.

| Hardware | Number Required | Military Standard | Resolver Size |
|---|---|---|---|
| Lock Washer | 12 EA | MS35338-135 | 15R26W4A |
| | 12 EA | " | 23R32W4A |
| | 8 EA | MS35338-136 | 23R3N4A |
| | 8 EA | " | 23R8N4A |
| | 8 EA | " | 23R32N4A |
| Terminal Lug | 8 EA | MS17182-2 | 11R7N4A |
| | 8 EA | " | 11R17N4A |
| | 7 EA | " | .25V-11R2N2A |
| | 7 EA | " | 26V-11R15N4B |
| | 7 EA | " | 26V-11R5N4A |
| | 7 EA | " | 9V-11R41N40A |
| | 12 EA | MS17187-3 | 11R20W4A |
| | 8 EA | " | 11R20N4A |
| Drive Washer | 8 EA | MS17186-6 | 11R7N4A |
| | 8 EA | " | 11R17N4A |
| | 8 EA | " | 15R28N4A |
| | 1 EA | " | 11R23W4A |
| | 1 EA | " | 15R2N4A |
| | 1 EA | " | 15R8N4A |
| | 1 EA | " | 15R28W4A |
| | 1 EA | " | .25V-11R2N2A |
| | 1 EA | " | 26V-11R15N4B |
| | 1 EA | " | 26V-11R5N4A |
| | 1 EA | " | 9V-11R41N40A |
| | 1 EA | " | 15R11W4A |
| | 1 EA | " | 15R26W4A |
| | 1 EA | " | 11R20W4A |
| | 1 EA | " | 11R20N4A |
| | 1 EA | " | 11R2N4B |
| | 1 EA | " | 11R1N4B |
| | 1 EA | " | 11R21N4B |
| | 1 EA | MS17186-8 | 23R3N4A |
| | 1 EA | " | 23R8N4A |
| | 1 EA | " | 23R32N4A |
| | 1 EA | " | 23R32W4A |
| | 1 EA | " | 23R58N4A |
| | 1 EA | " | 23R58W4A |

TABLE IV. Terminal hardware - Continued.

| Hardware | Number Required | Military Standard | Resolver Size |
|---|---|---|---|
| Nut | 8 EA | MS17187-2 | 11R7N4A |
| | 8 EA | " | 11R17N4A |
| | 8 EA | " | 15R28N4A |
| | 1 EA | " | 11R23W4A |
| | 1 EA | " | 15R2NRA |
| | 1 EA | " | 15R8N4A |
| | 1 EA | " | 15R28W4A |
| | 1 EA | " | .25V-11R2N2A |
| | 1 EA | " | 26V-11R15N4B |
| | 1 EA | " | 26V-11R5N4A |
| | 1 EA | " | 9V-11R41N40A |
| | 1 EA | " | 15R11W4A |
| | 1 EA | " | 15R26W4A |
| | 1 EA | " | 11R20W4A |
| | 1 EA | " | 11R20N4A |
| | 1 EA | " | 11R2N4B |
| | 1 EA | " | 11R21N4B |
| | 1 EA | " | 11R1N4B |
| | 1 EA | MS17187-3 | 23R3N4A |
| | 1 EA | " | 23R8N4A |
| | 1 EA | " | 23R32N4A |
| | 1 EA | " | 23R32W4A |
| | 1 EA | " | 23R58N4A |
| | 1 EA | " | 23R58W4A |

TABLE V. Standard dimensions for resolvers.

(See Figures 3, 4 and 5 for location of lettered dimensions)

| Dimension 1/ | A | B 2/ | C | D | E |
|---|---|---|---|---|---|
| Resolver Size | ±0.010 | ±0.010 | +0.000 -0.005 | +0.0000 -0.0005 | +0.0000 -0.0005 |
| 08 | AS LISTED ON SPECIFICATION SHEET TABLE II | | 0.750 | -- | 0.5000 |
| 11 | | | 1.062 | 1.0000 | 0.6250 |
| 15 | | | 1.437 | 1.3120 | 0.8750 |
| 23 | | | 2.250 3/ | 1.9995 4/ | 1.990 5/ |

| SPLINE DATA F | | | | Outside Diameter | Pitch Diameter | Root Diameter |
|---|---|---|---|---|---|---|
| Resolver Size | No. of Teeth | Diametral Pitch | Pressure Angle | +0.0000 -0.0005 | +0.0000 -0.0020 | Maximum |
| 11 | 21 | 120 | 20° | 0.1872 | 0.1750 | 0.155 |
| 15 | 21 | 120 | 20° | 0.1872 | 0.1750 | 0.155 |
| 23 | 22 | 96 | 20° | 0.2405 | 0.2291 | 0.205 |

NOTES:

1/ Unless otherwise specified, dimensions are in inches.

2/ B is length for full depth of tooth.

3/ Tolerance is +0.000/-0.001.

4/ Tolerance is ±0.0000/-0.0010.

5/ Tolerance is +0.000/-0.005.

TABLE V. Standard dimensions for resolvers - Continued.

(See Figures 3, 4, and 5 for location of lettered dimensions)

| Dimension | G | H | I | J | K |
|---|---|---|---|---|---|
| Resolver Size | ±0.005 | ±0.005 | ±0.005 | ±0.005 | ±0.005 |
| 08 | AS LISTED ON SPECIFICATION SHEET TABLE II | 0.040 | — | 0.062 | 0.062 |
| 11 | | 0.062 | 0.062 | 0.093 | 0.062 |
| 15 | | 0.040 | 0.132 | 0.093 | 0.078 |
| 23 | | 0.250 | 0.170 | 0.250 | 0.203 |

| Dimension | L | M | M' | N | N' |
|---|---|---|---|---|---|
| Resolver Size | ±0.005 | Minimum | Minimum | Minimum | Minimum |
| 08 | 0.687 | — | — | — | — |
| 11 | 0.975 | 0.300 | 0.180 | 0.146 | 0.250 |
| 15 | 1.312 | 0.308 | 0.190 | 0.166 | 0.253 |
| 23 | — | 0.333 | 0.280 | 0.156 | 0.382 |

TABLE V. Standard dimensions for resolvers - Continued.

(See Figures 3, 4, and 5 for location of lettered dimensions)

| Dimension | O | P | Q | R | S | T |
|---|---|---|---|---|---|---|
| Resolver Size | ±0.003 | ±0.003 | ±0.003 | ±0.005 | Maximum | +0.000 -0.005 |
| 08 | — | — | — | — | — | — |
| 11 | 0.812 | 0.062 | 0.125 | 0.812 | 0.020 | 0.506 |
| 15 | 1.100 | 0.062 | 0.125 | 1.075 | 0.060 | 0.665 |
| 23 | — | 0.062 | 0.125 | 1.437 | — | 0.064 6/ |

| Dimension | U | V | W | X | Z |
|---|---|---|---|---|---|
| Resolver Size | +0.0000 -0.0002 | Minimum | ±0.005 | ±0.010 | Maximum |
| 08 | AS LISTED ON SPECIFICATION SHEET TABLE II | 0.245 | — | — | 0.750 |
| 11 | | 0.285 | — | 0.069 | 1.062 |
| 15 | | 0.450 | — | 0.117 | 1.437 |
| 23 | | — | 0.595 7/ | 0.463 8/ | 1.990 |

NOTE:

6/ Tolerance is ±0.010.

7/ Type 23R3N4A and 23R32N4A resolvers have a W dimension of 0.600.

8/ Tolerance is ±0.005.

TABLE VI. Test voltages and application points.

| Maximum rated voltage, rms | Initial Test Voltages, rms (50 or 60 Hz) | | Subsequent Test Voltages rms (50 or 60 Hz) | |
|---|---|---|---|---|
| | Each winding to housing and primary to secondary windings | Between electrically separate windings in intimate contact | Each winding to housing and primary to secondary windings | Between electrically separate windings in intimate contact |
| Up to 50 | 242 to 250 | 242 to 250 | 194 to 200 | 194 to 200 |
| 51 to 100 | 485 to 500 | 242 to 250 | 388 to 400 | 194 to 200 |
| 101 to 200 | 870 to 900 | 242 to 250 | 720 to 740 | 194 to 200 |

TABLE VII. First article and quality conformance inspection tests.

| Test No. | Requirement | Test | Test method for examination | Inspection | |
|---|---|---|---|---|---|
| | | | | First Article Sample Number | Quality Conformance |
| 1 | 3.6.1 | 4.11.1 | Visual and mechanical inspection | 1, 2, 3, 4 | X |
| 2 | 3.6.2 | 4.11.2 | Shaft radial and end play | 1, 2, 3, 4 | X |
| 3 | 3.6.3 | 4.11.3 | Total shaft runout (smooth portion) | 1, 2, 3, 4 | X |
| 4 | 3.6.4 | 4.11.4 | Variation of brush contact resistance | 1, 2, 3, 4 | X |
| 5 | 3.6.5 | 4.11.5 | Mechanical breakaway torque | 1, 2, 3, 4 | X |
| 6 | 3.6.6 | 4.11.6 | Dielectric withstanding voltage | 1, 2, 3, 4 | X |
| 7 | 3.6.7 | 4.11.7 | Insulation resistance | 1, 2, 3, 4 | X |
| 8 | 3.6.8 | 4.11.8 | Current | 1, 2, 3, 4 | X |
| 9 | 3.6.9 | 4.11.9 | Power | 1, 2, 3, 4 | X |
| 10 | 3.6.10 | 4.11.10 | Transformation ratio | 1, 2, 3, 4 | X |
| 11 | 3.6.10.4 | 4.11.10.4 | Equality of transformation ratios | 1, 2, 3, 4 | X |
| 12 | 3.6.11 | 4.11.11 | Phase shift | 1, 2, 3, 4 | X |

TABLE VII. First article and quality conformance inspection tests - Continued.

| Test No. | Require-ment | Test | Test method for examination | Inspection | |
|---|---|---|---|---|---|
| | | | | First Article Sample Number | Quality Conformance |
| 13 | 3.6.12 | 4.11.12 | Function error 1/ | 1, 2, 3, 4 | X |
| 14 | 3.6.13 | 4.11.13 | Electrical error 1/ | 1, 2, 3, 4 | X |
| 15 | 3.6.14 | 4.11.14 | Residual (null) voltage | 1, 2, 3, 4 | X |
| 16 | 3.6.15 | 4.11.15 | Interaxis error 1/ | 1, 2, 3, 4 | X |
| 17 | 3.6.16 | 4.11.16 | Impedance | 1, 2, 3, 4 | X |
| 18 | 3.6.17.1 | 4.11.17.1 | Compensating residual voltage 1/ | 1, 2, 3, 4 | X |
| 19 | 3.6.17.2 | 4.11.17.2 | Compensating winding phase 1/ | 1, 2, 3, 4 | X |
| 20 | 3.6.18 | 4.11.18 | Resolver zero marking | 1, 2, 3, 4 | X |
| 21 | 3.6.19 | 4.11.19 | Security of terminals or wire leads | 1, 2, 3, 4 | - |
| 22 | 3.6.20 | 4.11.20 | Harmonic distortion | 1, 2, 3, 4 | - |
| 23 | 3.6.21 | 4.11.21 | Shift of resolver zero | 1, 2, 3, 4 | - |
| 24 | 3.6.10.3 | 4.11.10.3 | Transformation ratio variation of voltage | 1, 2, 3, 4 | - |

TABLE VII. First article and quality conformance inspection tests - Continued.

| Test No. | Require-ment | Test | Test method for examination | Inspection | |
|---|---|---|---|---|---|
| | | | | First Article Sample Number | Quality Conformance |
| 25 | 3.6.11.3 | 4.11.11.3 | Phase shift variation of voltage | 1, 2, 3, 4 | - |
| 26 | 3.6.22 | 4.11.22 | Resonant frequency response | 1, 2, 3, 4 | - |
| 27 | 3.6.23 | 4.11.23 | Temperature rise | 1, 2, 3, 4 | - |
| 28 | 3.6.24 | 4.11.24 | Electromagnetic interference | 1, 2, 3, 4 | - |
| 29 | 3.7.1 | 4.12.1 | Vibration, followed by test nos. 2, 4, 5, 6, 7, 13, 14, and 15 | 1, 2, 3, 4 | - |
| 30 | 3.7.2.1 | 4.12.2.1 | Shock, low impact, followed by test nos. 2, 4, 5, 6, 7, 13, 14 and 15 | 1, 2, 3, 4 | - |
| 31 | 3.7.3.1 | 4.12.3.1 | Altitude, low temperature during which test nos. 4 and 7 shall be performed | 1, 2 | - |
| 32 | 3.7.3.2 | 4.12.3.2 | Altitude, high temperature during which test nos. 4, 7 and 27 shall be be performed | 1, 2 | - |
| 33 | 3.7.5 | 4.12.5 | Endurance followed by test Nos. 2, 4, 5, 6, 7, 13, 14, and 15 | 1, 2 | - |
| 34 | 3.7.4.1 | 4.12.4.1 | Ambient, low temperature during which test nos. 4, 5, 6, 7, 13 and 14 shall be performed | 3, 4 | - |

TABLE VII. First article and quality conformance inspection tests - Continued.

| Test No. | Requirement | Test | Test method for examination | Inspection | |
|---|---|---|---|---|---|
| | | | | First Article Sample Number | Quality Conformance |
| 35 | 3.7.4.2 | 4.12.4.2 | Ambient, high temperature during which test nos. 4, 5, 6, 7, 13, 14, and 15 shall be performed | 3, 4 | - |
| 36 | 3.7.6 | 4.12.6 | Moisture resistance followed by test nos. 4, 5, 6, 7, 13, 14 and 15 | 3, 4 | - |
| 37 | 3.7.7 | 4.12.7 | Explosion resistance 1/ | 1, 2 | - |
| 38 | 3.7.8 | 4.12.8 | Salt atmosphere 1/ | 1, 2 | - |
| 39 | 3.7.2.2 | 4.12.2.2 | Shock, high impact, followed by test nos. 2, 4, 5, 6, 7, 13, 14 and 15 | 1, 2, 3, 4 | - |

*Test Nos. 13, Function error; 14, Electrical error; 15, Interaxis error; 18, Compensating residual voltage; 19, Compensating winding phase; 37, Explosion resistance; and 38, Salt atmosphere shall be performed only when required by the specification sheet.

TABLE VIII. Transformation ratio equality winding combinations.

| Primary Energization Winding | Shorted Winding | Secondary Winding | Rotor Angle |
|---|---|---|---|
| S1S3 | S2S4, C2C4 | R1R3 | 0° |
| S1S3 | S2S4, C2C4 | R2R4 | 270° |
| S2S4 | S1S3, C1C3 | R2R4 | 0° |
| S2S4 | S1S3, C1C3 | R1R3 | 90° |
| R1R3 | R2R4 | S1S3 | 0° |
| R1R3 | R2R4 | S2S4 | 90° |
| R2R4 | R1R3 | S2S4 | 0° |
| R2R4 | R1R3 | S1S3 | 270° |

Transformation ratio equality rotor/compensatory windings by calculation

| R/C Winding Calculation Based on R/S and C/S Measured Values | Rotor Angle |
|---|---|
| $\dfrac{\dfrac{R1R3}{S1S3}}{\dfrac{C1C3}{S1S3}} = \dfrac{R1R3}{C1C3}$ | 0° |
| $\dfrac{\dfrac{R2R4}{S2S4}}{\dfrac{C2C4}{S2S4}} = \dfrac{R2R4}{C2C4}$ | 0° |
| $\dfrac{\dfrac{R1R3}{S2S4}}{\dfrac{C2C4}{S2S4}} = \dfrac{R1R3}{C2C4}$ | 90° |
| $\dfrac{\dfrac{R4R2}{S1S3}}{\dfrac{C1C3}{S1S3}} = \dfrac{R4R2}{C1C3}$ | 90° |

TABLE IX. Residual voltage and interaxis error connections and angular displacements.

| Unit | Primary Voltage | Measurement Points | Rotor Electrical Angle | Interaxis Serial |
|---|---|---|---|---|
| Rotor Energized | R1R3 (R2R4 shorted) | S2S4 | 0° | A |
| | | S2S4 | 180° | B |
| | | S1S3 | 90° | C |
| | | S1S3 | 270° | D |
| | R2R4 (R1R3 shorted) | S1S3 | 0° | E |
| | | S1S3 | 180° | F |
| | | S2S4 | 90° | G |
| | | S2S4 | 270° | H |
| Stator Energized | S1S3 (S2S4 shorted) | R2R4 | 0° | A |
| | | R2R4 | 180° | B |
| | | R1R3 | 90° | C |
| | | R1R3 | 270° | D |
| | S2S4 (S1S3 shorted) | R1R3 | 0° | E |
| | | R1R3 | 180° | F |
| | | R2R4 | 90° | G |
| | | R2R4 | 270° | H |

TABLE X. Impedance measurements.

| Impedance | Terminals for Impedance Measurements (each winding tested separately) | Voltage Across Resolver Terminals | Additional Connections |
|---|---|---|---|
| Zro | R1R3, R2R4 | See 4.9 | 1/ |
| Zso | S2S4, S1S3 | See 4.9 | 1/ |
| Zrs | R1R3, R2R4 | 2/ | 3/ |
| Zss | S2S4, S1S3 | 4/ | 3/ |
| Zco | C2C4, C1C3 | See 4.9 | 5/ |

NOTES: 1/ Remaining energizing winding short circuited and all other windings open circuited.

2/ The voltage necessary to induce a current within ± 3 percent of current in Zro measurement.

3/ All other windings except compensating windings short circuited.

4/ The voltage necessary to induce a current within ± 3 percent of current in Zso measurement.

5/ Remaining compensating winding short circuited and all other windings open circuited.

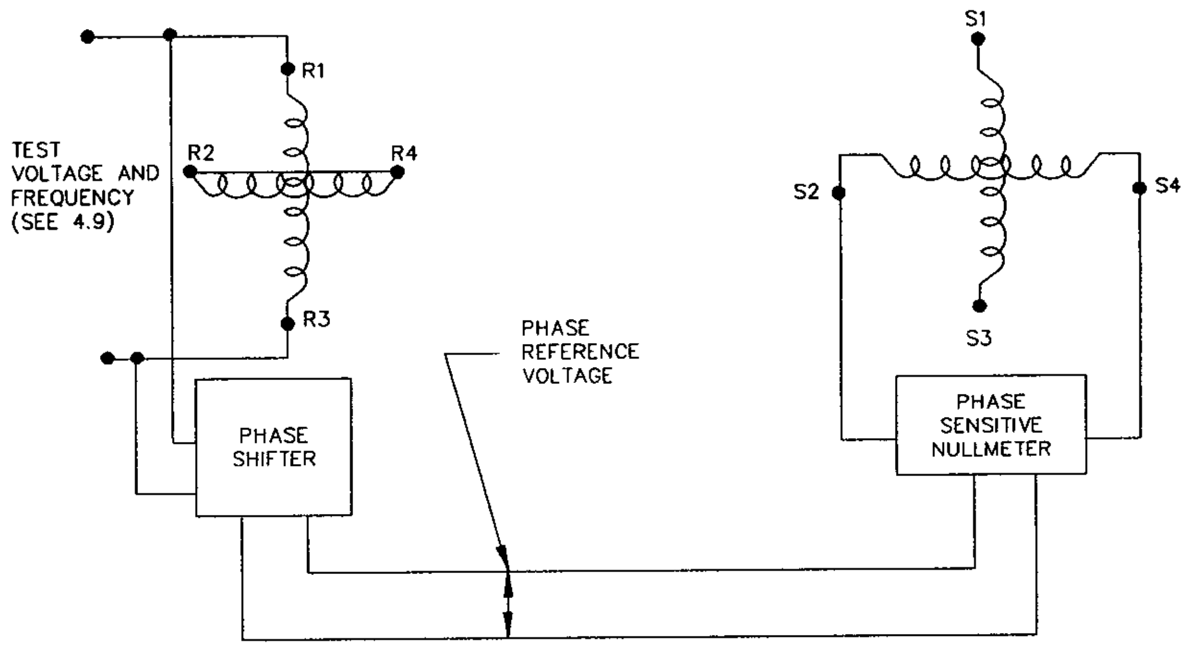



FIGURE 1. Resolver zero, rotor-energized resolvers.

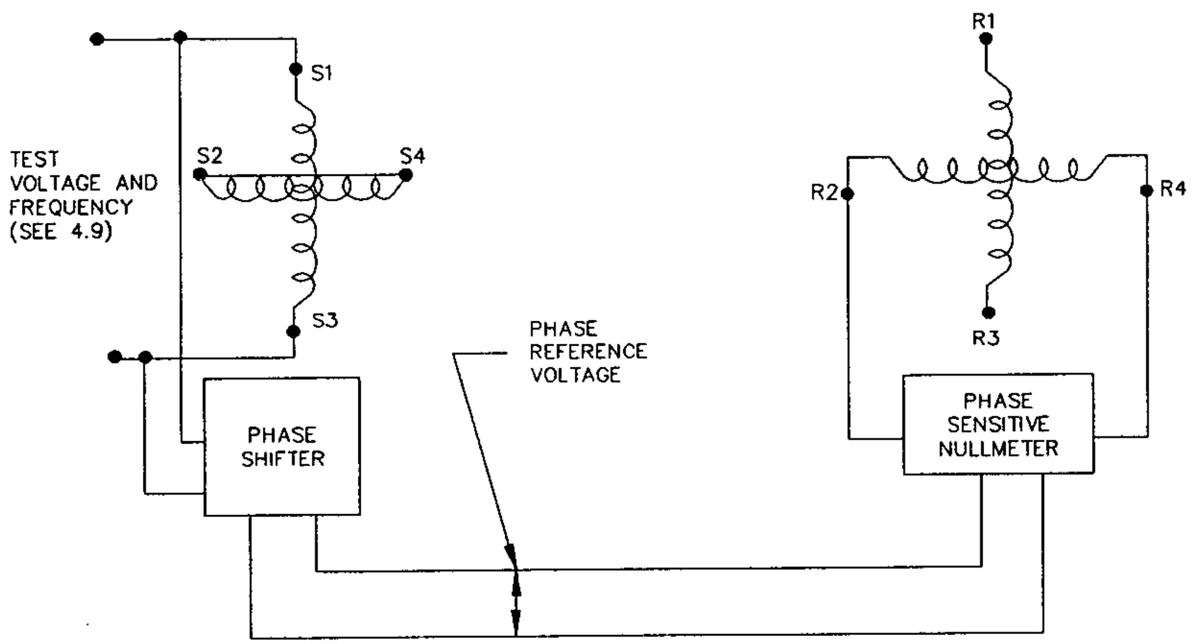
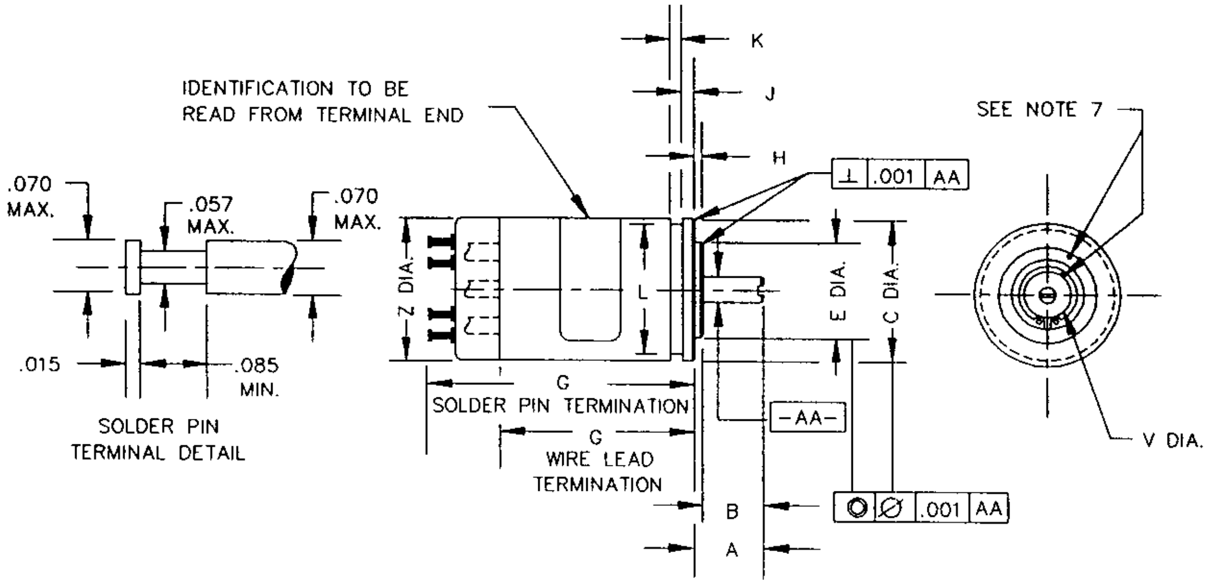
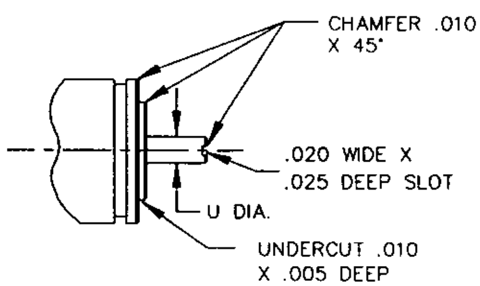
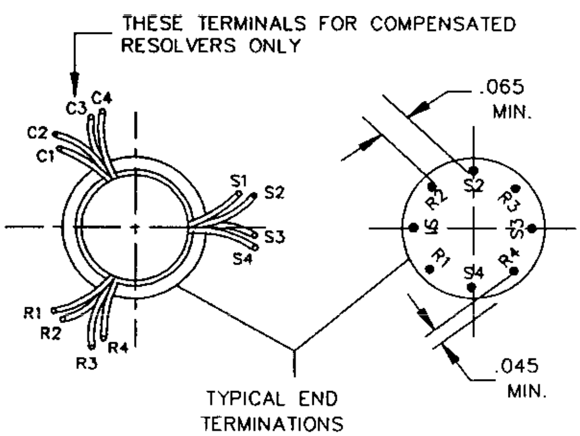



FIGURE 2. Resolver zero, stator-energized resolvers.




NOTES:

1. PERPENDICULARITY AND CONCENTRICITY SHALL BE MEASURED WITH THE UNIT IN A VERTICAL POSITION SUPPORTED BY THE SHAFT, THEN THE HOUSING SHALL BE ROTATED.

2. TOTAL RUNOUT OF MAJOR DIAMETER OF FEATURE -AA- SHALL NOT EXCEED .0008 FIM.

3. END PLAY AND RADIAL PLAY SHALL BE MEASURED DURING REVERSAL OF THE FOLLOWING LOADS:

   END PLAY - 1/2 LB     RADIAL PLAY - 1/4 LB

4. TERMINAL LEAD WIRES SHALL DEPART THROUGH THE BACK SURFACE OF THE TERMINAL END OF THE RESOLVER IN ANY ACCEPTABLE MANNER.

5. MINOR VARIATIONS OF UNIT CONFIGURATION ARE PERMITTED FOR UNDIMENSIONED DESIGN DETAIL.

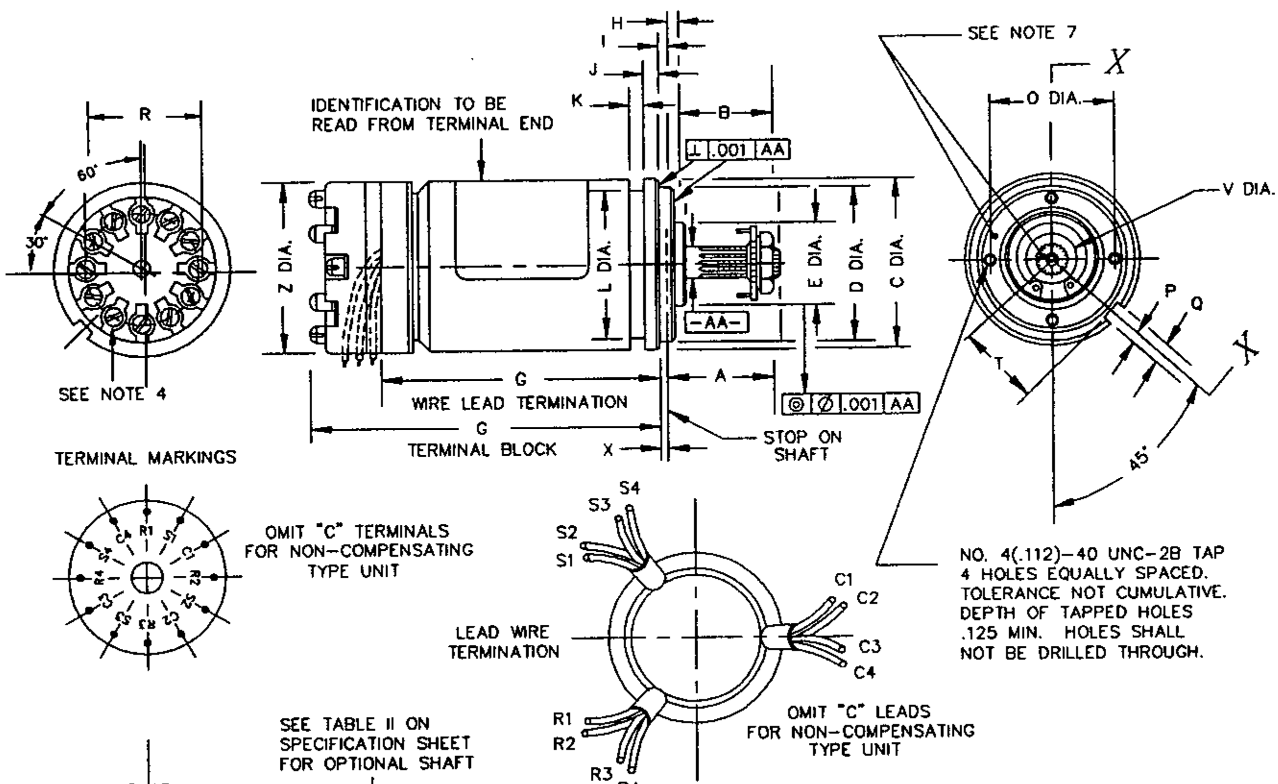
6. UNLESS SPECIFIED OTHERWISE, DIMENSIONS ARE IN INCHES. TOLERANCES SHALL BE: FRACTIONS ±1/64, DECIMALS ±.005, AND ANGLES ±2°.

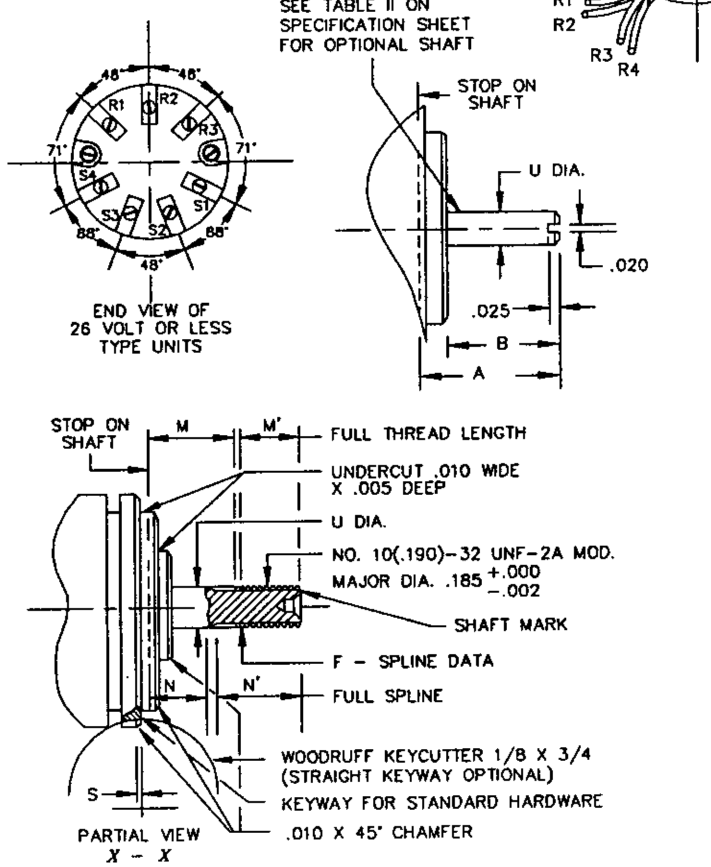
7. MARK ON HOUSING IS TO BE ALIGNED WITH SHAFT MARK WITHIN 10° WHEN ROTOR IS SET AT APPROXIMATELY RESOLVER ZERO AND WILL BEAR NO RELATION TO THE CENTER LINES SHOWN ON THE DRAWING.

8. THE FRONT RETAINER SHALL EITHER BE THREADED OR A SNAP RING.

9. LETTERED DIMENSIONS ARE SHOWN IN TABLE V.

FIGURE 3. Outline drawing for size 08 resolvers.




NOTES:

1. PERPENDICULARITY AND CONCENTRICITY SHALL BE MEASURED WITH THE UNIT IN A VERTICAL POSITION SUPPORTED BY THE SHAFT, THEN THE HOUSING ROTATED.

2. TOTAL RUNOUT OF SMOOTH PORTION OF FEATURE -AA- SHALL NOT EXCEED .0008 FIM.

3. END PLAY AND RADIAL PLAY SHALL BE MEASURED DURING REVERSAL OF THE FOLLOWING LOADS:

   END PLAY - 1 POUND RADIAL PLAY - 1/2 POUND

4. THE TERMINAL BLOCK SHALL BE SECURED BY SCREWS OTHER THAN THE TERMINAL SCREWS. RECESSES SHALL ALLOW TERMINAL LUGS, MS-17182-1, TO BE INSTALLED WITH BARRELS INBOARD OR OUTBOARD, AND PREVENT THE LUGS FROM TURNING.

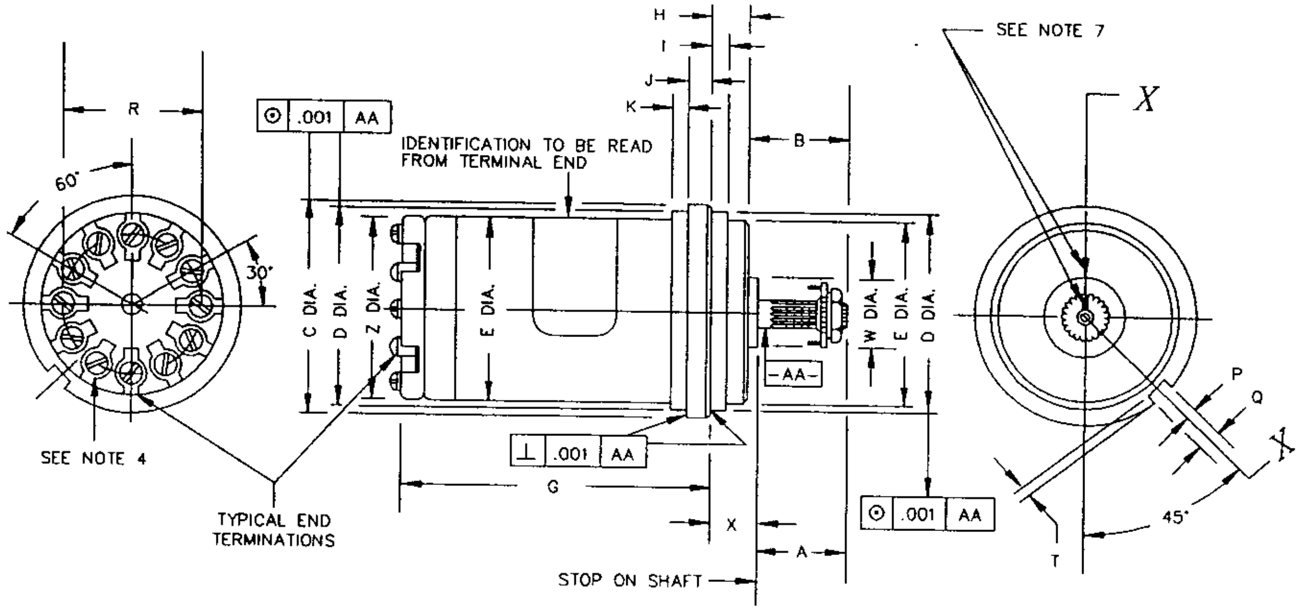
5. MINOR VARIATIONS OF UNIT CONFIGURATION ARE PERMITTED FOR UNDIMENSIONED DESIGN DETAIL.

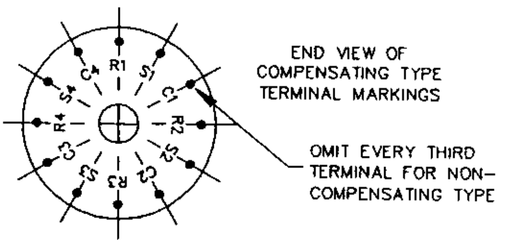
6. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES. TOLERANCES ON FRACTIONS ±1/64, ON DECIMALS ±.005, AND ON ANGLES ±2°.

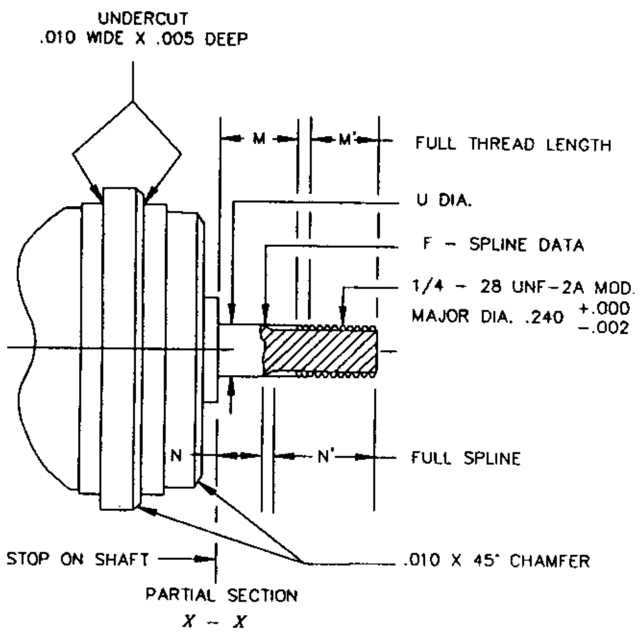
7. MARK ON HOUSING IS TO MATCH SHAFT MARK WITHIN 10° WHEN ROTOR IS SET AT APPROXIMATELY RESOLVER ZERO AND WILL BEAR NO RELATION TO THE CENTER LINES SHOWN ON THIS DRAWING.

8. LETTERED DIMENSIONS ARE SHOWN IN TABLE V.

FIGURE 4. Outline drawing for size 11 and 15 resolvers.




NOTES:

1. PERPENDICULARITY AND CONCENTRICITY SHALL BE MEASURED WITH THE UNIT IN A VERTICAL POSITION SUPPORTED BY THE SHAFT, THEN THE HOUSING ROTATED

2. RUNOUT OF THE SMOOTH PORTION OF FEATURE -AA- SHALL NOT EXCEED .0008 FIM.

3. END PLAY AND RADIAL PLAY SHALL BE MEASURED DURING REVERSAL OF THE FOLLOWING LOADS:

   END PLAY - 1 POUND RADIAL PLAY - 1/2 POUND

4. THE TERMINAL BLOCK SHALL BE SECURED BY SCREWS OTHER THAN THE TERMINAL SCREWS. RECESSES SHALL ALLOW TERMINAL LUGS, MS-17182-1, TO BE INSTALLED WITH BARRELS INBOARD OR OUTBOARD, AND PREVENT THE LUGS FROM TURNING.

5. MINOR VARIATIONS OF UNIT CONFIGURATION ARE PERMITTED FOR UNDIMENSIONED DESIGN DETAIL.

6. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES. TOLERANCES ON FRACTIONS ± 1/64, ON DECIMALS ± .005, AND ON ANGLES ± 2°.

7. MARK ON HOUSING IS TO MATCH SHAFT MARK WITHIN 10° WHEN ROTOR IS SET AT APPROXIMATELY RESOLVER ZERO AND WILL BEAR NO RELATION TO THE CENTER LINES SHOWN ON THIS DRAWING.

8. LETTERED DIMENSIONS ARE SHOWN IN TABLE V.

FIGURE 5. Outline drawing for size 23 resolvers.

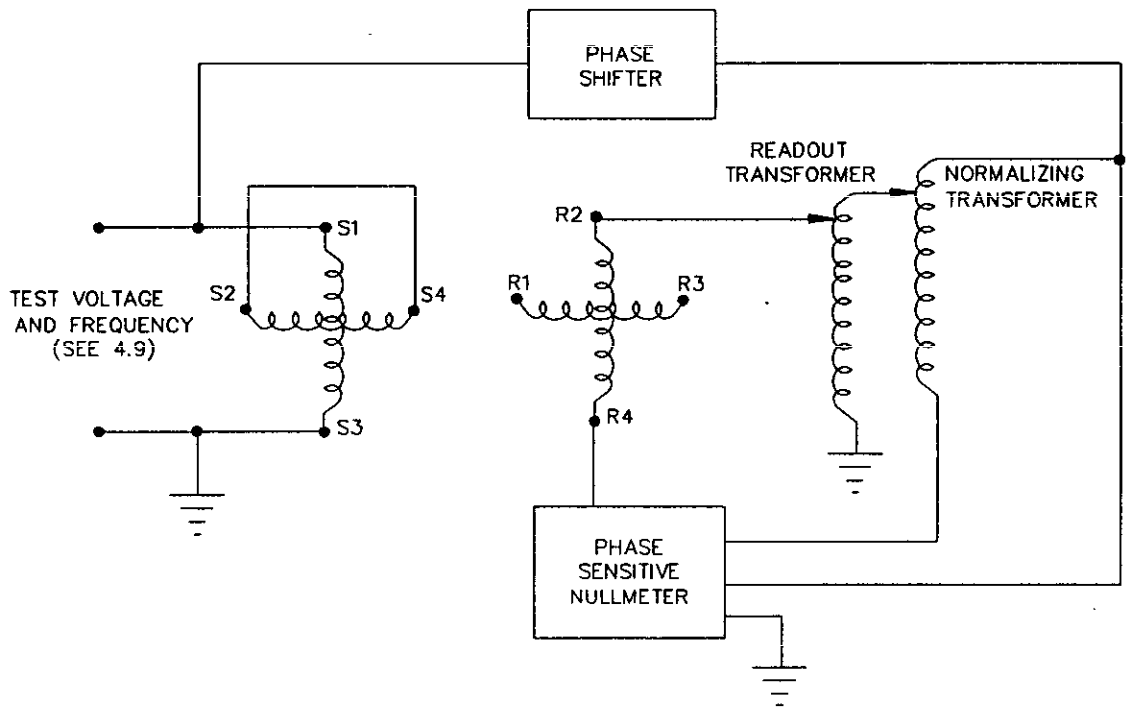



FIGURE 6. Function error test circuit.

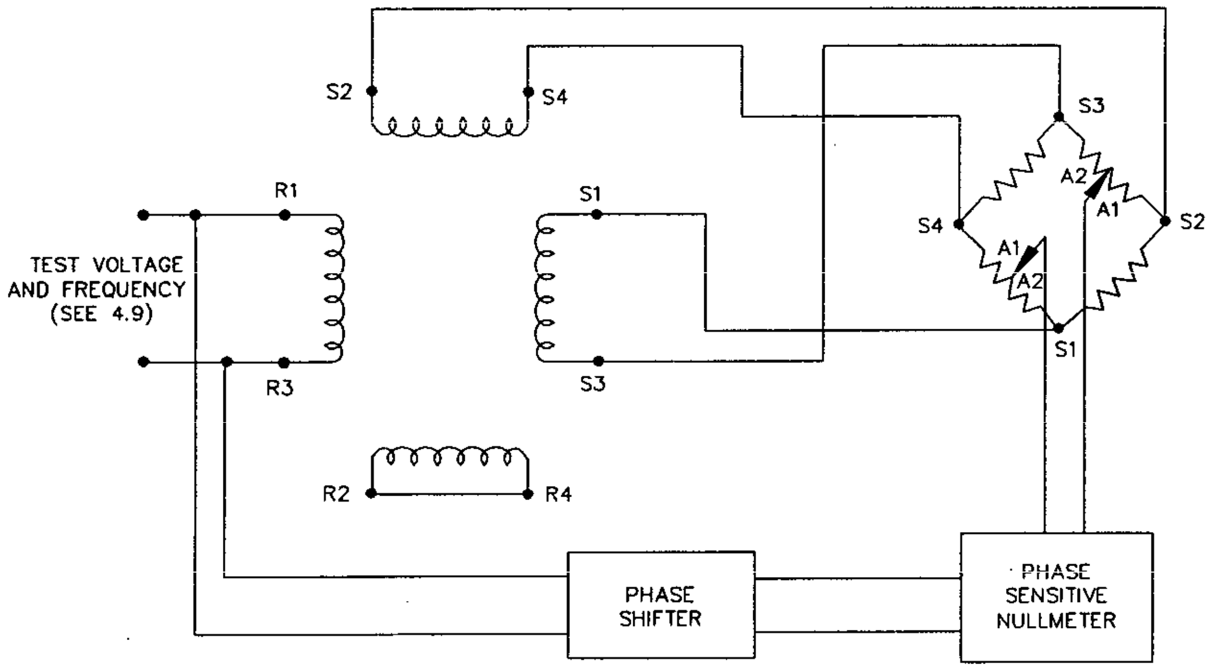



FIGURE 7. Basic circuit for stator electrical error test, rotor-energized resolvers, proportional voltage null method.

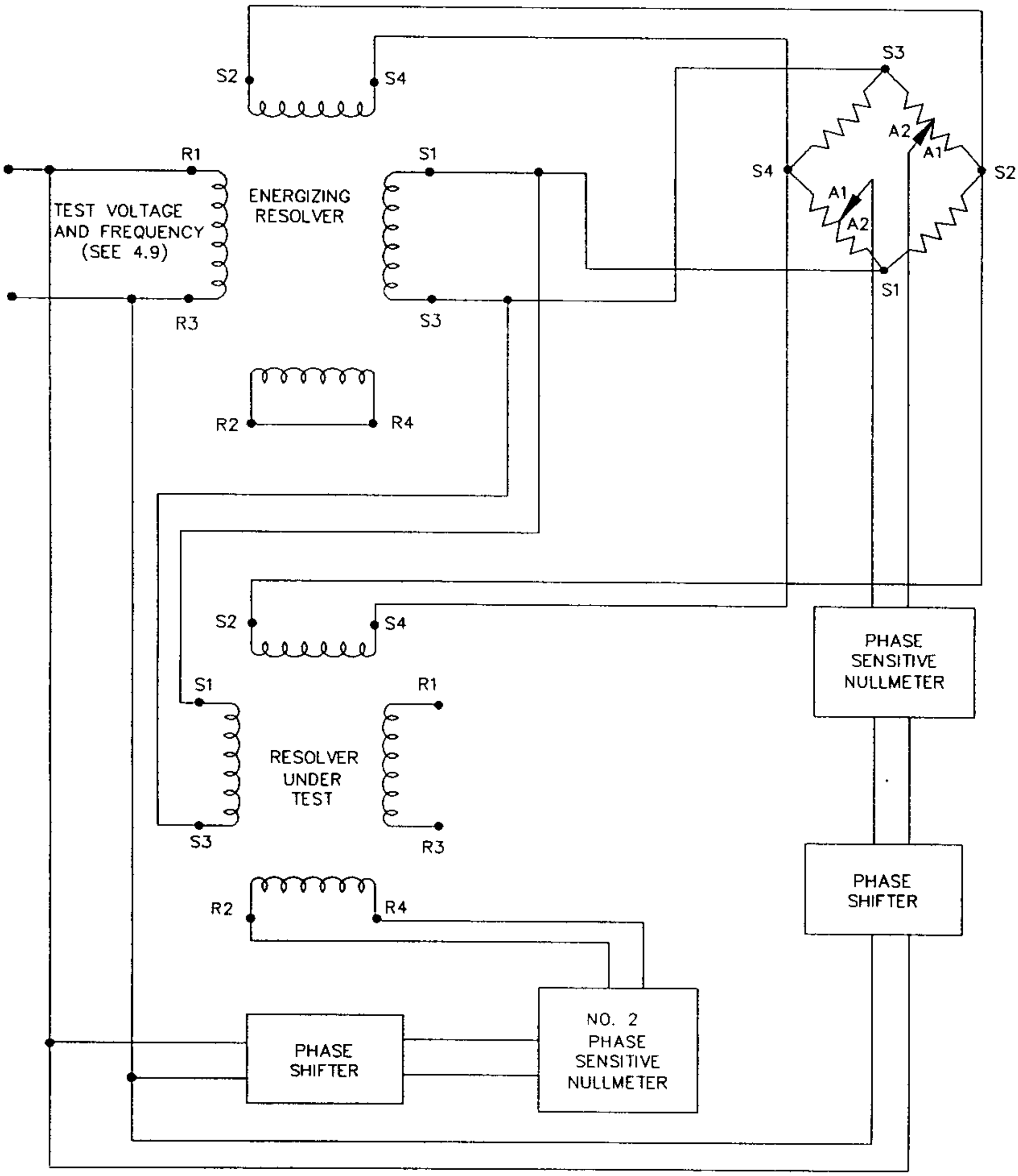



FIGURE 8. Basic circuit for stator electrical error test, stator-energized resolvers, proportional voltage null method.

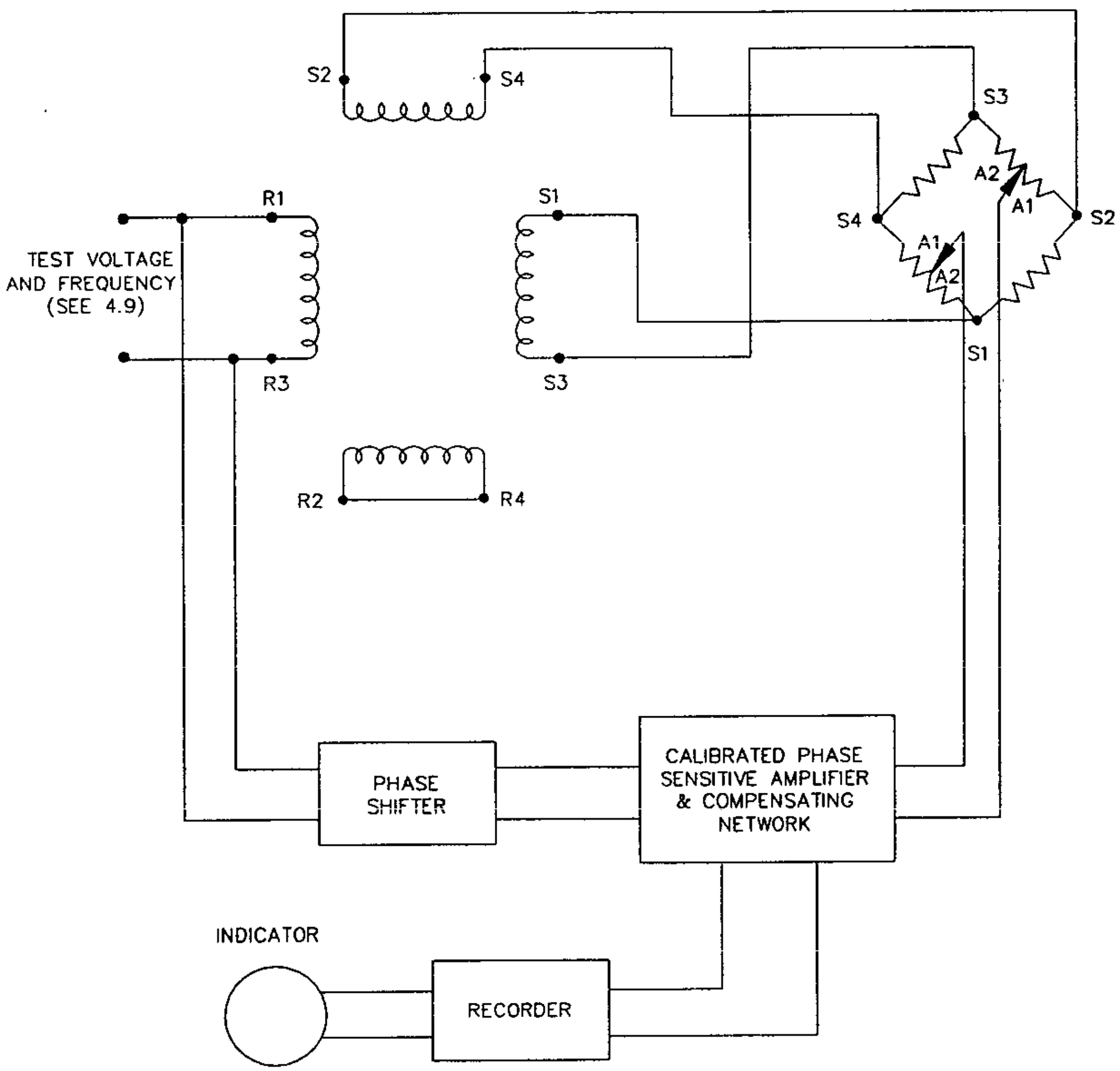



FIGURE 9. Basic circuit for stator electrical error test, rotor-energized resolvers, proportional voltage gradient method.

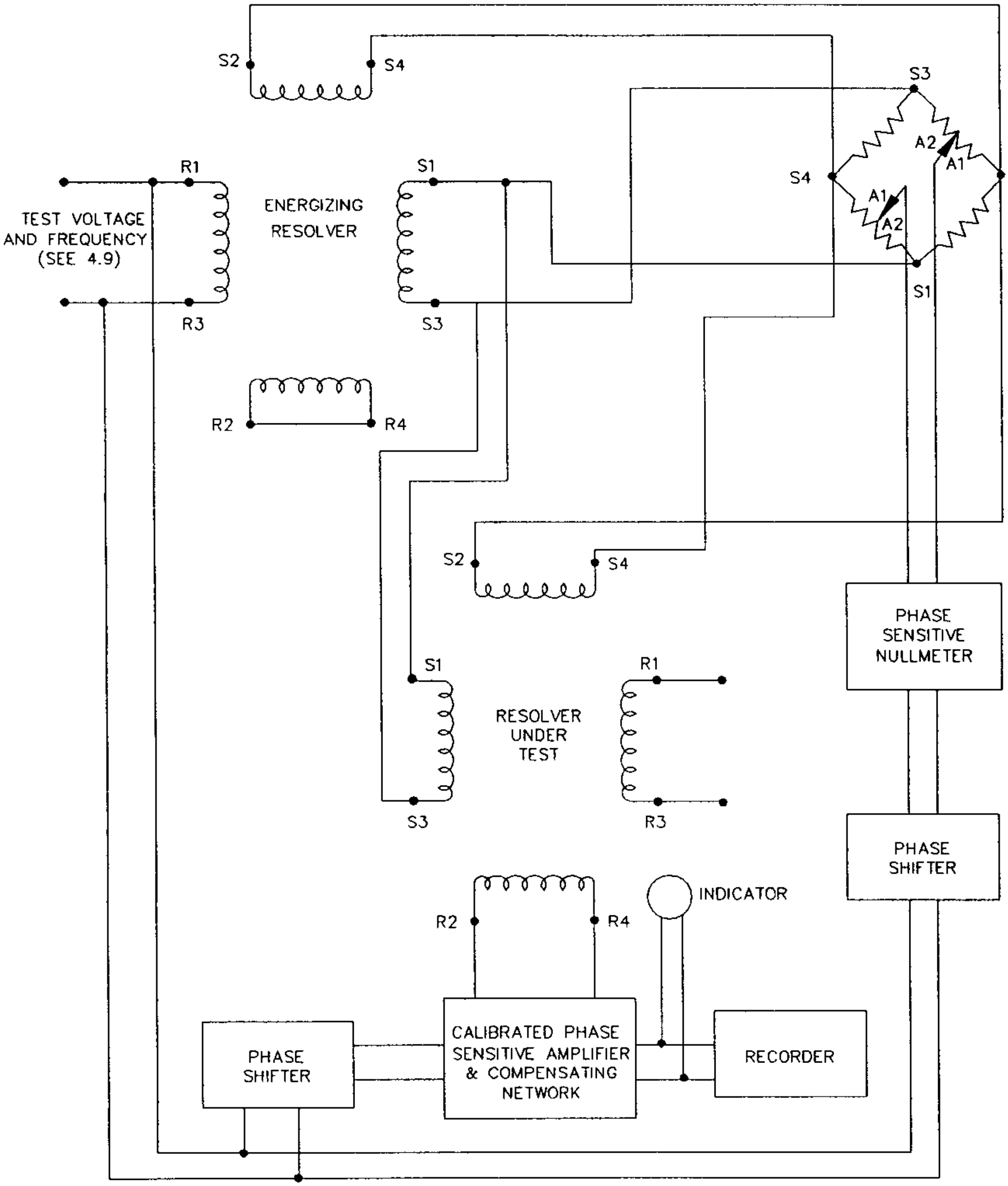
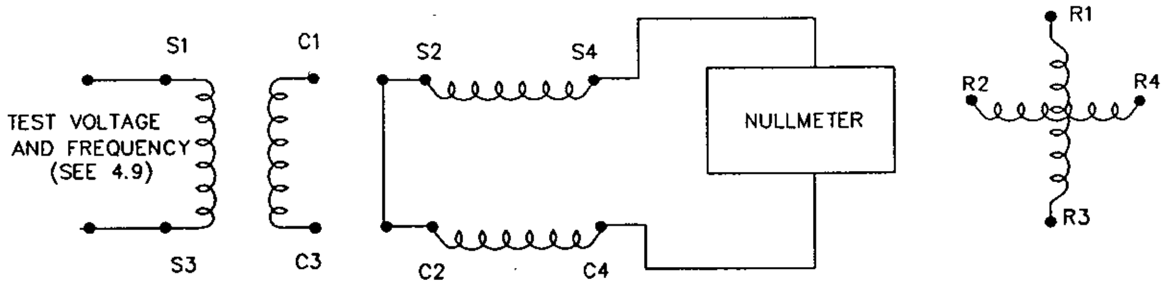
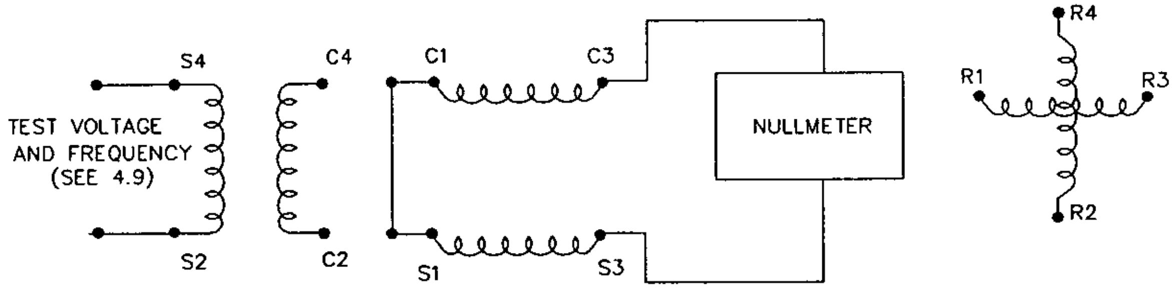



FIGURE 10. Basic circuit for stator electrical error test, stator-energized resolvers, proportional voltage gradient method.

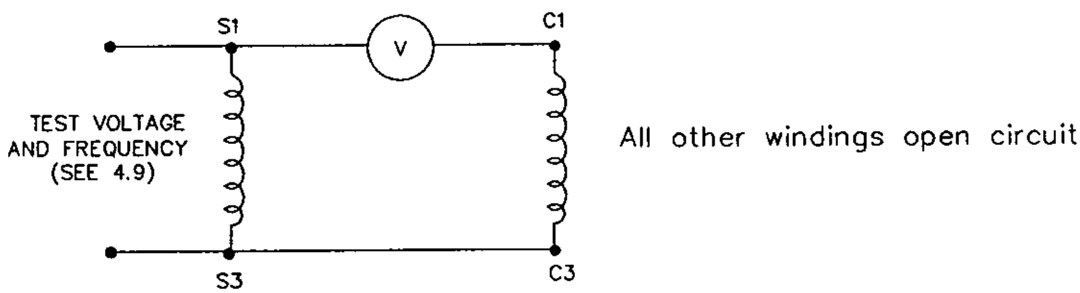



a. C2C4 Null

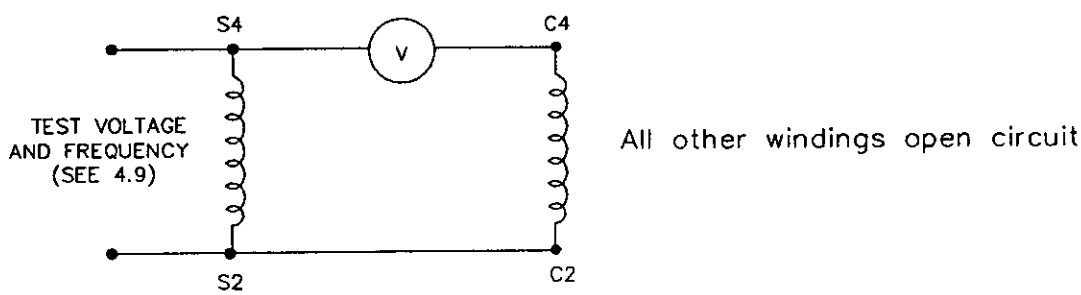



b. C1C3 Null

FIGURE 11. Residual voltage test circuits, compensating windings.




a. C1C3 Phasing




b. C2C4 Phasing

FIGURE 12. Winding phasing test circuits, compensating windings.

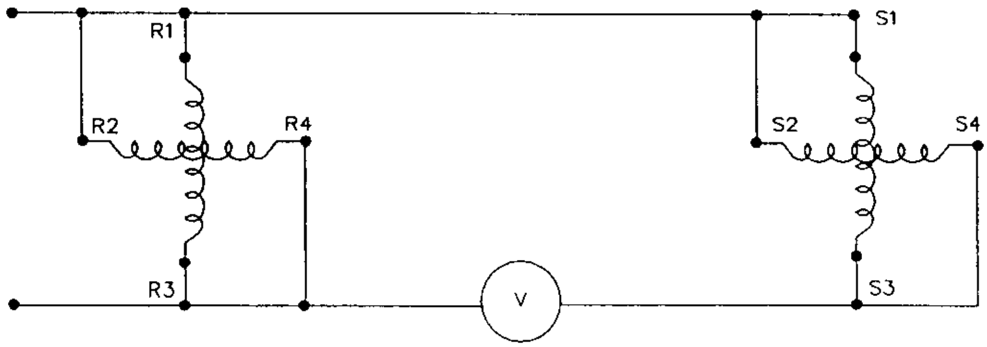



FIGURE 13. Resolver zero marking, rotor-energized resolver.

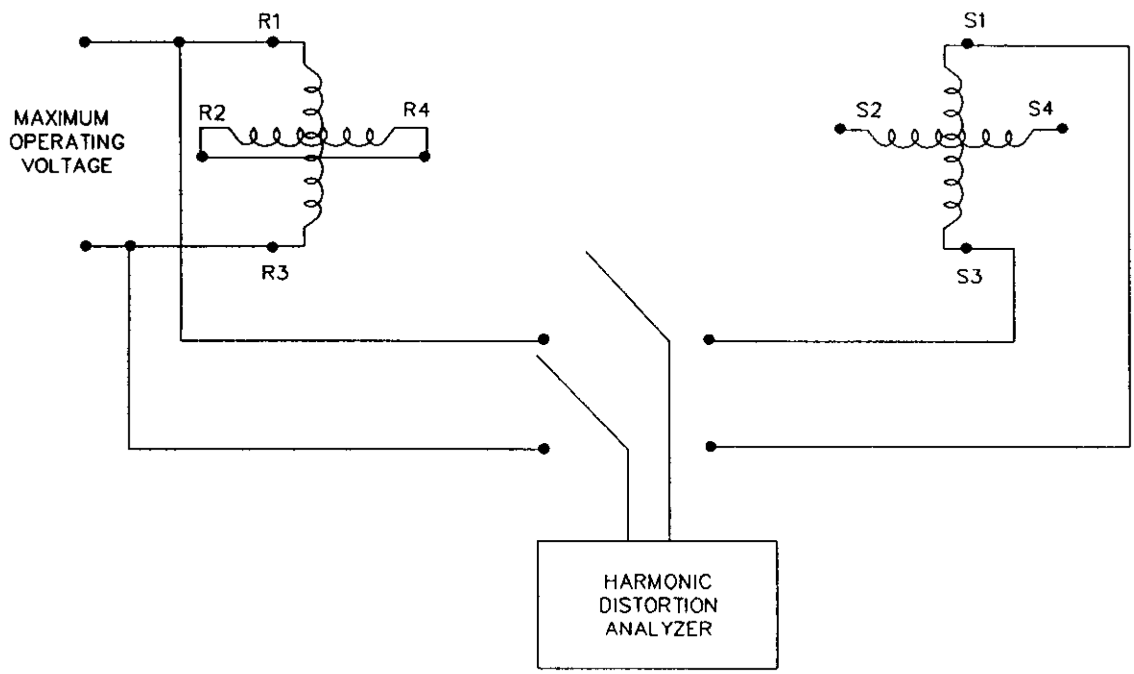



FIGURE 14. Harmonic distortion test circuit.

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